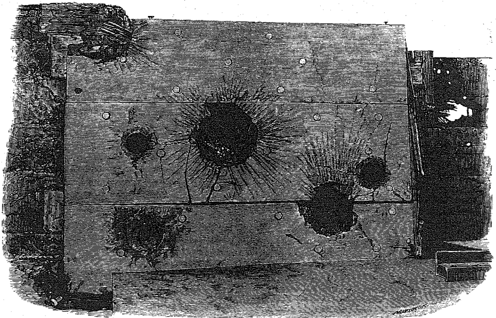
THE

STORY OF THE GUNS.

LONDON
PRINTED BY SPOTTISWOODE AND CO.
NEW-STREET SQUARE



IRON TARGET DESTROYED BY THE WHITWORTH AND HORSFALL GUNS.

THE

STORY OF THE GUNS.

BY

SIR J. EMERSON TENNENT,

K.C.S., LL.D., F.R.S., &c.

LONDON:
LONGMAN, GREEN, LONGMAN, ROBERTS, & GREEN.
1864.

PREFACE.

IT was my fortune at an early age to hold a commission as an officer of artillery in a foreign service, during a time of war. It was in the 'pre-scientific period,' and under circumstances which, however advantageous for observing the destructive powers of ordnance both by land and sea, were little favourable to the study of its construction. But they imparted an interest in the subject which recent occurrences have served to revive.

In the great controversy, which for the last few years has attracted attention to the guns of rival inventors in this country, I have no pretension to interfere either as a military commentator or an amateur theorist. But in addition to the inventors who are to produce the new artillery, and the naval and military service who are to use it, there is *a third party* interested in the investigation;—the nation at large, who look to acquire an effective armament in return for the expenditure incurred. As one of the latter I enquired without success for any published state-

ment, calculated to give in the order of time and occurrence a consecutive memoir of what has taken place since the war in the Crimea, in connection with the improvement of rifled arms. Finding that none such existed, I have compiled the present volume, in the hope to supply the want, so far as concerns the progress made in England—what has been done elsewhere is beyond the scope of my undertaking.

In addition to personal observation of the results of experiments with artillery, my information has been drawn from such records as are accessible to the public: papers laid before Parliament, evidence taken by successive Committees of the House of Commons, discussions in the theatres of scientific institutions, addresses delivered to large assemblies on special occasions, reviews and periodicals, reports of the press upon the marvellous powers of the new ordnance as displayed from time to time at various points of the coast, and the comments of writers devoted exclusively to mechanical science in its application to the art of war.

From these and similar sources it has been my aim to collect such materials as are calculated to disclose the former state of things that rendered the demand for improvement imperative, and to exhibit at each stage the advance made by successive inventors, all contributing to bring the question to that point in which it now awaits solution.

One series of topics I have scrupulously shunned,

beyond the merest mention (when such was unavoidable) that such points had been mooted; I mean the never-ending and apparently inscrutable claims of inventors to priority of discovery. I have found throughout the course of this enquiry, that with a curiously infelicitous uniformity, there is not a single feature in any one of the recently patented improvements in gunnery—from the metal of which a cannon is made to the form of the bore and the configuration of the projectile—that has not been the object of contested claims and the source of vituperative animosity. Were we to credit the open assaults and the secret imputations, not on one only, but apparently on almost all the eminent engineers at present engaged in the study of rifled arms, the otherwise inadmissible conclusion would be inevitable, that the most exalted men in this important department must be included in Pope's estimate of Bacon, as

> The wisest, brightest, *meanest* of mankind.

I have passed by such discussions, not from any disrespect to the distinguished individuals whom they concern, but from a conviction that the conclusions, to whichever side they may lean, can have no practical weight as regards the momentous decision which the country is now called upon to make. Such claims honourably adjusted will form brilliant epochs in the biography of science, but as personal incidents or chronological disquisitions they cannot with propriety be

permitted to divert the attention of the nation from the paramount object of acquiring for the equipment of its forces the arms most conducive to security in peace, and to supremacy in war.

J. EMERSON TENNENT.

LONDON: *Nov. 2, 1863.*

CONTENTS.

PART I.

THE RIFLED MUSKET.

CHAPTER I.

'BROWN BESS.'

CHAPTER II.

IMPROVEMENT BEGINS—LORD HARDINGE AND MR. WHITWORTH.

CHAPTER III.

THE 'SECRET' DISCOVERED—THE WHITWORTH RIFLE.

PART II.

RIFLED ORDNANCE.

CHAPTER I.

RIFLED CANNON—CAST-IRON AND WROUGHT-IRON GUNS.

CHAPTER II.

THE ARMSTRONG GUN.

CHAPTER III.

THE WHITWORTH GUN—

ADOPTION OF THE ARMSTRONG GUN BY THE WAR DEPARTMENT.

CHAPTER IV.

SIR WILLIAM ARMSTRONG'S OFFICIAL RELATION TO THE GOVERNMENT.

CHAPTER V.

THE CONTEST.

PART III.

THE IRON NAVY.

CHAPTER I.

THE NATION RESOLVE TO CONSTRUCT A NAVY OF IRON.

CHAPTER II.

IRON SHIPS DEFY ARTILLERY.

CHAPTER III.

WHITWORTH PROJECTILES PENETRATE ARMOUR-CLAD SHIPS.

CHAPTER IV.

THE WHITWORTH SHELLS PENETRATE ARMOUR-PLATE.

CONCLUSION.

THE PRESENT ASPECT OF THE QUESTION.

LIST OF ILLUSTRATIONS.

PART I.

THE RIFLED MUSKET.

CHAPTER I.

'BROWN BESS.'

WITHIN the ten years that have elapsed since the outburst of the war in the Crimea, the improvements and discoveries in the construction of fire-arms and projectiles have exceeded, both in number and importance, all that occurred since the reign of Henry VIII. From the year 1628, when Arnold Rotsipen obtained from Charles I. letters-patent for 'a new waye or meanes of makeinge gonnes, whereof a patterne and proofe was shewn to the King's selfe,' down to the end of 1852, not more than three hundred patents had been issued for inventions; whereas more than double that number were granted within the next seven years.[1]

On looking now at the specimens of early small arms and artillery preserved in museums and arsenals, it is surprising how little change has been undergone, either by ordnance or musketry, during that long period of comparative inaction. Except in the superior composition of the metal, cannon cast in the reigns of

[1] *Abridgments of the Specifications relating to Fire-arms*, &c. Printed by order of the Commissioners of Patents, 1859, p. 1.

the Georges exhibited little alteration or improvement beyond their condition in the time of Elizabeth. The muskets borne by our soldiers in the Peninsula and at Waterloo differed in no essential particular from those with which their ancestors fought at Blenheim and Ramilies; and the substitution of the percussion-cap for a flint-lock took place at a still later period. Military weapons were allowed to retain all their primitive rudeness, whilst the utmost care and ingenuity were exerted to bring sporting guns to perfection. Money and skill were bestowed without stint on a rifle to bring down a deer; or on a fowling-piece with which a pheasant was to be shot; but any weapon, however clumsy, was thought sufficiently good when the issue of a battle or the fate of an empire was in the balance.[1]

Nor was this display of apathy confined to England alone. Almost every other nation in Europe concurred in manifesting the same contented indifference. Marmont, to the close of his life, upheld the old musket as the most formidable and effective of all possible weapons; and Napoleon withdrew the rifle from the Imperial troops, to whom it had been partially issued during the wars of the Republic; nor was it restored to the French armies till after the invasion of Algeria, in 1830, when it was adopted for the equipment of the Chasseurs d'Orléans.[2] Prior to that time, however, some perception of the superiority of the rifle had

[1] *Edinburgh Review*, 1859, p. 515. It used to be a simile applied by gamekeepers to a bad fowling-piece, 'Why, sir, she be of no more use nor a soger's musket.'—*Examiner*, Nov. 8, 1862.

[2] Delvigne, *Notice Historique des Armes Rayées*, p. 57.

begun to be felt in Great Britain, after its efficiency had been witnessed in the hands of the Americans, whose marksmen were indebted to its skilful use for their advantages over ourselves; as well as for subsequent successes in their expeditions against the Mexicans.

Gradually, the antiquated musket came to be regarded with distrust. It was so incorrectly bored, and the windage so great[1] that the bullets flew wild as they left the barrel. 'Brown Bess,' from being the boast became the bye-word of the British army. Those who had previously extolled her sturdy endurance began to 'gird at' her infirmities; and disrespectful allusions were made to illustrate her errors and decrepitude. Although officially said to be effective at a range of 200 yards, it was the working rule of the soldier to reserve his shot *till he saw the whites of his enemy's eyes*, and even then it was said that, before he could bring down his man, he must fire a full weight of his body in lead.

It has been questioned whether, without the invention of the bayonet, the musket of the last century would have permanently superseded the crossbow of the middle ages. And it admits of no doubt, that, often in our own times, the consciousness of the

[1] 'Windage' is the difference between the diameter of the shot and the bore of the piece from which it is fired, owing to which an unoccupied space is left between the projectile and the inner circumference of the gun. In practice the effect of windage in smooth bore pieces is to force the ball against one side of the barrel, whence it rebounds against the other, making a zigzag motion in its exit, which is fatal to its steady flight.

defects of the firelock impelled our men to resort to the strong and certain thrust of the bayonet, rather than to rely for their safety on the chance performances of the clumsy and capricious 'Brown Bess.' Nor was there wanting authoritative testimony to sustain this mistrust. At the battle of Salamanca only 8,000 men were put *hors de combat*, although 3,500,000 cartridges were fired, together with 6,000 cannon balls, (besides which there were charges both of cavalry and the line;) so that, as regards the line, only one shot in 437 took effect. 'An officer engaged at Waterloo says that he could not see more than three or four saddles emptied by the fire of one side of a square of British infantry upon a body of French cavalry close to them; yet Bonaparte complimented our men on the superior steadiness of their aim. During the Continental campaigns, he and his marshals held that 450 yards was a safe distance from all small arms, the rifle included.'[1] Colonel Wilford, in the course of a lecture delivered at the United Service Institution, in London, in November 1859, stated that during the Caffre War 80,000 cartridges were fired in a single engagement, in which only *twenty-five* of the enemy fell.

An engineer officer, who in one of the great battles of the last war had an opportunity of witnessing the effect of musketry upon cavalry charging a square, states that a volley at thirty paces brought down only three men. The French admit that during the Crimean war they fired away upwards of 25,000,000 cartridges, and

[1] *Spectator*, March 19, 1859.

certainly did not hit 25,000 men nor kill one-half that number by musketry-fire.[1] 'We believe,' says the *Times*,[2] writing about that period, that 'the calculation used to be that one bullet in 250 carried death; and that estimate is probably not far from the truth.'

As early as the year 1838 a series of experiments were undertaken by the officers of the Royal Engineers at Chatham, to ascertain what the properties of the service musket really were. The 'result,' says the *Edinburgh Review*, 'was certainly most amusing. The target first employed was 3 feet wide and 11 feet 6 inches high, which was struck by about three-fourths the balls at 150 yards, fired with full charges — with reduced charges only above one-half hit. Above this distance, the difficulty of hitting was so great, that the width of the target had to be increased to six feet; and, at 250 yards, of ten shots fired with full charges, not one hit the target: at 300 yards shot after shot was fired without one hitting the object aimed at, or its whereabouts being ascertained. After various expedients in vain resorted to to hit such an object at such a range, the officers gave it up in despair; and proceeded to calculate a table of "instructions for soldiers," in firing with the musket, some of which will appear strange at the present day. The soldier was told, in firing at a man, at 600 yards, *to fire* 130 *feet above him!* or in other words, if you wish to hit a church-door aim at the weather-cock. But considering the lateral deviation, the chances were

[1] *Edinburgh Review*, April 1859, p. 525.
[2] *Times* April 24, 1857.

certainly two to one that you would miss the church altogether.'[1]

Not very long ago, a well-trained marksman, provided with an old regulation musket, was placed to fire at a target 18 feet square from a distance of 300 yards, and found that he could not put even into that spacious area *one bullet out of twenty*. At 200 yards his success was not greater, and yet the fire-arm thus tested was the regular weapon of the British soldier, so late as the year 1852.

Although it anticipates, to some extent, the thread of the following narrative, I may be permitted here to notice, that on the occasion on which this exposure of the old pattern musket was made, the improved rifle which had then recently been issued was brought forward, under precisely the same circumstances, and scarcely a shot missed the target; demonstrating, that if a soldier can be enabled to hit uniformly, where he hit but once out of twenty times before, his increased value is equivalent to an addition to the numbers of the army in precisely that proportion. Not only so, but the distance at which the new weapon could kill having been increased from one or two hundred yards to fourteen hundred, or more, it came to be felt, that unless *artillery* could be improved in the same ratio as the rifle, the old ordnance would be rendered useless, as gunners would be picked off and killed before their cannon could be brought within range.

Whether it was ascribable to the form of the bore and

[1] *Edinburgh Review*, April 1859, p. 520.

the shot, to windage, to defects of construction, or to a combination of all—*ordnance* both for field and sea service was, down to a very recent period, almost as ineffective as the musket of the infantry. The windage allowed was excessive; the charge of powder consequently large; and the spherical shot, which by its gravity fell to the lower side of the piece, being started with its centre eccentric to the bore, bounded irregularly along the barrel (causing serious wear by indentation) and issued from the muzzle sometimes high, sometimes low, and sometimes on one side, but seldom or never in a line with the axis of the gun. Thus, accuracy of firing was and is, in similar pieces, almost impossible to be attained.

Again, the round shot on issuing from the gun presents so large a diameter to the action of the air that its speed is soon retarded, and the force of the wind acting on it laterally, its course becomes deflected and uncertain. When Dr. Hutton was conducting his experiments on atmospheric resistance to projectiles, at a reach of the Thames adjacent to Woolwich, he found that, in order to hit a target at the distance of a mile, it was necessary to point the gun 400 yards to the right or left, according to the direction and force of the wind.

In siege operations and in naval warfare, the ammunition wasted was far in excess of the injury done to the enemy; so much so, that after the fall of Sebastopol, the surface of the plateau in the vicinity of the captured citadel was strewn with balls as with the products of a

mine of ready-wrought iron.[1] Against stone-works and fortresses like Sveaborg and Cronstadt the assault of guns such as were then in use was instinctively felt to be powerless; and the fate of actions at sea—even those most formidably contested—was frequently decided less by the destructive power of artillery than by fierce hand-to-hand struggles between boarding parties and the crew.

To drive a projectile into, if not through, an enemy's ship, has at all times been esteemed the first essential of a *naval gun*;[2] but so defective was our ordnance in penetrative power, that attention was mainly directed to the means of increasing the damage done by bruising, and the wide dispersion of splinters. Hence conflicts were prolonged with increased mutilation and slaughter, instead of being early and decisively determined by displays of irresistible might; and in renowned engagements, such as that between the Chesapeake and the Shannon, the vast majority of the missiles discharged —spherical shot as well as bar-shot and chain—were found imbedded in the timbers, whilst those that penetrated the ship were comparatively few.

So far as regards the army, it has been usual to ascribe the long endurance of the old state of things to the alleged obstinacy of the Duke of Wellington, who

[1] A friend of mine who was present during the siege wrote to me as follows: — 'I hardly exaggerate in saying that over some dozen acres a smart fellow might have crossed every yard of ground upon iron, without laying a foot on the earth. The cannon shot were *thick* in some places, and scattered in others, but the coup d'œil was indescribable!'

[2] Sir HOWARD DOUGLAS *on Naval Gunnery*, 108, p. 77.

is always represented as having been hostile to change in matters of military equipment, and wilfully blind to the defects of the old musket. Earl Grey when examined before a committee of the House of Commons 'on *Military Organisation*' in 1860, said it was 'notorious to all the world, that the Duke objected in the strongest manner to giving up the old musket.'[1] Tardy justice has been accorded to his Grace in this particular. So far from being opposed to improving the armament of troops, his personal friend and biographer, the Chaplain-General of the Forces, has placed on record that the Duke of Wellington was often heard to say that, 'looking to the amount of mechanical skill in the country, and the numerical weakness of our army as compared with those of the great continental powers, British troops ought to be the best armed soldiers in Europe.'[2]

Whilst duly aware of the imperfections both of small arms and ordnance, the Duke was equally competent to form a correct estimate of the difficulties which beset their removal; but amongst these he did not for a moment admit the force of military *routine*, which, next to rash innovation, Napoleon III. has pronounced to be the most redoubtable enemy to all improvement,[3] regarding errors as sacred only because they are old.

[1] Evidence, 5368, p. 389.

[2] Gleig's *Life of the Duke of Wellington*, p. 548.

[3] 'La routine amoureuse des vieilles pratiques a conservé pendant des siècles les usages les plus stupides. . . . La routine conserve scrupuleusement comme un dépôt sacré les vieilles erreurs; mais elle s'oppose

The obstructions apparent to the Duke of Wellington were such as his experience had taught him to discern. As First Minister of the Crown, he had shown himself a rigid economist by the largest possible reductions in every branch of the public expenditure; [1] and hence he felt the responsibility of adopting proposed additions to military expenditure. But besides this, his observation as a practical administrator, both in the field and in the cabinet—not only as Commander-in-Chief but as Master-General of the Ordnance—had taught him the wholesome necessity of caution in introducing into the service, as ostensible amendments, inventions in fire-arms which were in reality only the *early and immature germs of experiments still incomplete.* Without discountenancing science, or discouraging ingenuity, his habit in relation to alleged improvements was to wait till scientific investigation had demonstrated the principle to be true, and till practical experience had proved their construction to be sound. 'He considered it necessary,' said Lord Herbert, 'that

encore de toutes ses forces aux améliorations les plus légitimes et les plus évidentes.'—*Du Passé et de l'Avenir de l'Artillerie, Œuvres de* NAPOLÉON III, tome iv^me, Avant-propos, pp. 15, 16, 17.

[1] 'There was nothing of which the Duke was more jealous than of proposals which involved, or threatened to involve, any addition to the cost of maintaining the army. His scruples on that head originated in two sources. As a minister and a statesman he was perhaps the most rigid economist of modern times. He effected larger reductions in the public expenditure during the brief period of his administration than had been effected before, or have been effected since, by any other head of the government, within the memory of man. Hence his common expression, "Depend upon it, gentlemen, the greatest enemies the army has in this country are those who would add *unnecessarily* to its expense."'—GLEIG's *Life of the Duke of Wellington*, p. 547.

those enquiries should be made *before* he gave to changes the sanction of his high authority.'[1] Proceeding on any other system, it is obvious that in the great majority of cases the public money would have been squandered by the temporary adoption of novelties, which a very brief trial might have rendered it necessary to discard. The wisdom of the Duke of Wellington was displayed in prudently abstaining from regarding theories as established so long as they are only rudimental; or accepting results as demonstrated when the experiments on which they were dependent were still preliminary and inchoate. Although better qualified than any other authority of his time to appreciate the exploits achieved by the old musket, the Duke, so far from being a partisan of 'Brown Bess,' gave his sanction to its supersession by the Minié rifle, in 1851. But before authorising its distribution to the service, he justified the measure in his own mind, not only by the example of the French and Belgian experiments, but by personal inspection of the ease with which the gun could be managed by the men, and the facility afforded by it for loading. It gave place a few years after to the Enfield; and slight as was the superiority which the Minié, when first introduced, presented over the antiquated musket of the previous century, its partial introduction by the Duke of Wellington was the only improvement that up to that time had been made in the construction of small arms.

[1] Committee of the House of Commons on *Military Organisation*, 1860; 6499, p. 450.

In the two most formidable wars that have signalised the present decade; that in which Russia was repulsed in her attempted invasion of the Ottoman Empire, and that by which Bengal was rescued from the revolted sepoys of India; we had, in the latter instance, to face envenomed foes whom we ourselves trained to the use of arms, and who had learned from us all the deficiencies of the only weapons with which we had to encounter them;—and in the other, we had to confront an enemy whose ambition was uniformly directed to render his armies the most formidable in Europe; whilst by the association of our force with that of France we were brought into trying contrast with an ally whose pride and policy were equally involved in having arms as well as discipline brought to the highest attainable perfection. Yet, notwithstanding the wish expressed by the Duke of Wellington, in 1852, that every soldier of the line should be armed with a rifle, it was recently stated in the House of Commons[1] (I know not how correctly) that one division, at least, of the British army in the Crimea was provided with no better weapon than 'Brown Bess.'[2]

[1] Lord Elcho, June 6, 1861.

[2] It is fair, however, to state that the French army in the Crimea were but indifferently provided, for although the Chasseurs carried the *carabine à tige* (of which there is some notice in the next chapter), the infantry were armed with the smooth bore regulation musket. See Sir Howard Douglas *on Naval Gunnery*, 600, p. 571.

CHAPTER II.

IMPROVEMENT BEGINS—LORD HARDINGE AND MR. WHITWORTH.

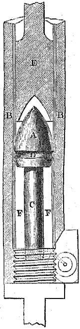
LORD HERBERT OF LEA has borne a generous testimony to the claims of Viscount Hardinge on the gratitude of England 'as the person to whom the army owes most, for the improvement of weapons of war, and for carrying out the changes with regard to the rifle with the greatest energy and determination.'[1]

Lord Hardinge became Master-General of the Ordnance in 1852, and succeeded the Duke of Wellington as Commander-in-Chief at the close of the same year. Previous to his entrance upon these high offices, the career of improvement in France had begun, and numerous attempts had been made in this country to remedy the defects of the old musket; but Lord Hardinge, although not the first, had the good fortune to be the most successful in instituting a systematic and sustained effort for the adaptation of the rifle to the service of the army.

The French, as already stated, had abandoned the use of the rifle at an early stage of the revolutionary war; and

[1] *Evidence before the Committee of the House of Commons on Military Organisation*, 6504, p. 457.

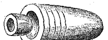
it was not till after the restoration of the dynasty that it was reintroduced. In 1826 Captain Delvigne proposed the system which has since borne his name, but which was only a modification of the former rude plan of forcing the ball into the grooves of the barrel by smart blows of the ramrod. In 1842 the 'Delvigne rifle' was superseded by the *Carabine à tige* of Colonel Thouvenin, in which, in order to impart rotation to the ball, a pillar was screwed into the breech, so as to leave surrounding space for the powder; and against the end of this '*tige*' the bullet was flattened by the ramrod, till its base became expanded, and being forced into the grooves it assumed the form of the rifle barrel. One advantage of this system was that the bullet, when resting on the top of the pillar, did not press upon the powder, or, as it is technically said, 'meal' it, when struck with the ramrod. To this M. Delvigne superadded the further improvement of substituting a projectile, the bottom of which was flat, the sides cylindrical, and the front terminated conically, somewhat resembling Sir Isaac Newton's 'solid of least resistance.'[1]



THE CARABINE À TIGE.

[1] *Principia*, L. ii. Schol. to Prop. 34. In the accompanying sketch taken from Sir Howard Douglas, *Naval Gunnery*, p. 137, the Delvigne

The *Carabine à tige*, furnished with Delvigne's projectiles, was the arm supplied to the *chasseurs d'Afrique* in 1846, during the war in Algeria. But the 'pillar' was found liable to become bent; and being otherwise objectionable, it was superseded by the introduction of the Minié ball, the peculiarity of which was that, being made smaller than the bore of the piece, it could be almost dropped loose into the barrel, and it contained in its base a conical recess, to receive the apex of a cup of iron, somewhat larger than the opening, into which it was to be driven by the explosion, and thus to effect at once its own expansion and rifling.[1]



THE MINIÉ BALL.[2]

Other countries were not less active than France. The Prussians attained some success in the attempt to load their rifles at the breech instead of the muzzle, and armed their troops with the 'zündnadelgewehr,' which is discharged by passing a needle into the cartridge, so as to ignite percussion powder placed within.

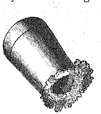
ball is seen at A, furnished with a groove D near the base to admit of its attachment to the cartridge by means of a cord. B B represents the barrel; C the '*tige*' or pillar, screwed into the face of the breech-pin; E the ramrod; and F F the space round the pillar for containing the powder.

[1] The original contrivance of a self-expanding projectile is said to belong to Mr. Greener, who proposed a ball of this construction in 1836. See a *Paper on Projectiles*, by F. A. Abel, Esq., Chemical Director of the War Department at Woolwich, in the *Practical Mechanics' Journal*, 1862, p. 455.

[2] This and the following engraving, p. 18, are copied from Scoffern's work on *Projectiles and Weapons of War*, pp. 240, 241.

The Americans, too, had obtained celebrity from a rifle firing conical bullets or 'pickets' with such accuracy, that one instance was adduced in which ten consecutive shots at 220 yards were planted within a space no larger than a small playing card — a feat which up to that period was considered unequalled. Down, however, to the accession of Lord Hardinge to the Master-Generalship of the Ordnance, the only practical improvement in England had been the partial introduction of the Minié bullet for the rifle, which took place when the Marquis of Anglesey, as Master-General in 1851, ordered the issue of 28,000 Regulation rifled muskets.[1]

But the Minié ball, notwithstanding its superiority in many particulars, exhibited grave disadvantages;



THE MINIÉ BALL DISTORTED.

its tendency to fouling was considerable—the distended portions of the projectile sometimes detached themselves and clogged the grooves, rendering loading extremely difficult — and occasionally the iron cup,

[1] The dimensions of this Minié musket will give some idea of its cumbrous character: the barrel was 4 lbs. 10 oz.; it had a bore of ·702 in., with 4 rifled grooves, having one turn in 6 ft. 6 in.; and the bullet adapted to it weighed 680 grains.

instead of merely expanding the lead, was driven completely through the opposite extremity, converting the bullet into a distorted tube, which sometimes remained firmly fixed in the barrel.

In the Enfield bullet, which was adopted in 1853, a wooden plug was substituted for the iron cup.

THE ENFIELD BULLET.

It is a question, whether eventually both iron and wood may not be got rid of, since it is found that the expansion of a leaden ball, if hollowed at the base, can be effectually attained simply by the force of the explosion, when the metal driven outwards, finds its first and great resistance in the 'lands,' or smooth parts of the barrel left untouched by the rifling, against which it is pressed with great force, and thence overflows into the grooves.[1]

Embarrassed by defects inherent in different systems, one of the earliest measures of Lord Hardinge was the institution of a comprehensive enquiry into the whole subject of rifled arms and projectiles. He placed himself in communication with Mr. Westley Richards, Mr. Purdey, and others of the most eminent gun

[1] It has been suggested that the expansion is caused by the *vis inertiæ* of the leaden projectile; and the force acting endwise on the mass 'jumps it up,' as it is termed, in the middle.

makers in Great Britain. Six of these supplied pattern muskets of various diameters of bore, ranging from ·530 in. the smallest, to ·650 in. the largest.[1] Comparisons were also made of the weapons in use by the armies of other military powers, and information was collected from leading factories of Europe and the United States; and by the aid of the facts and suggestions thus acquired, the adoption of the musket since known as the 'Enfield rifle' was resolved on; and arrangements were put in progress for the organisation of a government factory, to be provided with machinery, chiefly on the American model, for shaping the various parts. Here it was proposed to commence at once the production of an arm for the British forces combining, it was hoped, the varied excellencies manifested in each of the pattern rifles sent in by the most eminent makers in England.

Such was the origin of the 'Enfield rifle' of 1853. It was stronger than its predecessor of 1851, and at the same time the musket and its sixty cartridges weighed three pounds less.[2] It was rifled with grooves and lands on the old system, with one turn in 6 feet 6 inches. Its diameter was ·577 of an inch, and at limited ranges it fired a bullet weighing 530 grains with great accuracy and force. During the ten years that have elapsed since its adoption, although other rifles made

[1] Col. A. Gordon, *Letter to* Sir C. Trevelyan *on National Defence*, 1853.

[2] The total weight of the Enfield and its sixty rounds of ammunition is 14 lbs. 6 oz. 11 dr.

in England have greatly exceeded it in almost every essential quality, it admits of no doubt that the Enfield rifle is still superior to any arm yet adopted in other countries,[1] and its efficiency was well attested at the Alma and at Inkermann, where, in the words of the 'Times' correspondent, 'it smote the enemy like a destroying angel.'

In spite of all the precautions of Lord Hardinge, however, the arrangements for the construction of a government establishment for the manufacture of rifles have not been without disappointments; and the Enfield, although incomparably the best that up to that time had been introduced into the service, has since disclosed numerous defects, which those who watched over the early stage of the experiment found it difficult to account for at the time. The velocity of the ball proved to be lower than had been looked for; its trajectory[2] was consequently higher, and its precision and penetration less; the tendency to foul was considerable, but what was above all embarrassing was, that *no two guns were alike in their properties or*

[1] See *Report of the Ordnance Select Committee*, presented to Parliament March 19, 1863.

[2] The 'trajectory' of a ball is the line which it describes between leaving the muzzle of the gun and reaching the object aimed at. As the gravity of the projectile imparts a downward tendency in its flight, no portion of the path of a shot through the air can be said to be a right line. In practice, this has to be taken into account by elevating the gun above the object to be fired at till it reaches the angle proportioned to the distance. Hence accuracy of aim is, under such circumstances, the result of complex and elaborate calculation, the necessity for which diminishes in proportion as increased velocity brings down the trajectory towards a level with the gun.

performance, although all underwent the same process, and were produced by the same means. 'One rifle shoots well,' says Lord Hardinge, 'another ill, and the eye of the best viewer can detect no difference in the gun to account for it.'[1]

The variance, in fact, was such as could only be conjectured to arise from some subtle imperfection in the manufacture; and in this emergency recourse was had to the advice and assistance of Mr. Whitworth of Manchester, a gentleman pronounced by the Secretary of State for the War Department to be 'the most celebrated mechanician of this country.'[2] For this eminence in his profession Mr. Whitworth is indebted to a natural aptitude for its cultivation, but mainly to an exhaustive knowledge of its principles and processes, acquired by unconquerable perseverance. Endowed with a taste for mechanics, and with something like an instinct for overcoming difficulties, he developed and disciplined his powers by serving in early life under the ablest masters, Maudslay, Clement, Holtzappfel, and others of the class whose genius and ability have raised mechanical art to its present high rank in England, especially by the improvement of those wonderful self-acting engines, which under the technical name of 'engine-tools,' (*machine-outils,*) are now so extensively used for working in metals, as well as for the production of other machines dependent on accuracy and precision.

[1] *Memorandum of* Lord HARDINGE, May 17, 1854, para. 6.

[2] *Ibid.* See also the debate in the House of Commons on the Enfield and Whitworth rifles, June 26, 1861, in which more than once Mr. WHITWORTH was spoken of as 'the greatest mechanical genius in Europe.'

Mr. Whitworth does not belong to the ordinary type of inventors, quick, versatile, and ingenious, acting from impulse or apparent inspiration; his productions, on the contrary, are the results of slow and deliberate thought, bringing former observation to bear upon tentative experiment and accepting nothing as established till it has undergone proof. Proceeding with a logical severity to rest further operations only on ascertained facts, his process is so strictly inductive, that he might justly be designated the Bacon of mechanics.

Hence his great reputation rests not so much on any one startling discovery, as on that general stamp of excellence, which he has been enabled to impress on the machinery of the United Kingdom. What he found rude and incomplete, he rendered as nearly as possible perfect, till there is scarcely an operation connected with the shaping of metal, in cutting, planing, turning, boring, slotting, or drilling it, to which he has not applied machines in supersession of hand labour, 'such as the world never saw before; unsurpassed both in excellency, in design, and in perfection of execution.'[1]

In the motion of the most perfect mechanism, as in the action of that human intelligence which it seems to emulate, there are qualities so essentially alike, that they have come to be designated by terms interchangeably appropriate to both: truth, firmness, and accuracy, simplicity, strength, and endurance, are epithets borrowed from the attributes of mind, and applied with equal

[1] *Record of the International Exhibition of* 1862, *Practical Mechanics' Journal*, p. 300.

significance to the structure and operations of machinery; and it was in the imparting of these to the inventions of which he became the author, that Mr. Whitworth achieved that reputation in his profession which all might envy, but which none is so selfish as to dispute.

Next to their singular ingenuity, and even more wonderful, in the estimation of those best qualified to judge, is that absence of complexity by which they are characterised; their construction being the simplest imaginable, consistently with efficiency and power; yet such is the delicate and undeviating accuracy of their performance, that of the multitude of articles produced by them, each can be made in form and dimension indistinguishable from the others.

For the attainment of this consummate perfection, it is the belief of Mr. Whitworth that the superiority of all machinery is dependent on two elements—the power of *measuring* with unerring precision, and, associated with it, the faculty of producing a *true plane surface*, that is, one so absolutely level that, when opposed to another of equal truth, their contact must be in all parts complete. The Astronomer Royal, Mr. AIREY, in his evidence before a committee of the House of Lords, in 1855, stated that the degree to which Mr. Whitworth had succeeded in 'making perfect the planing of surfaces was entirely unknown before his time.' To such a pitch of excellence has he brought it by a process peculiar to himself,[1] that a plate of metal prepared by him,

[1] See *Report of the Committee of the House of Lords on the Weights and Measures Bill*, 1855, p. 3. The process has been described in

when opposed to the face of another similarly treated, exhibits a contact so intimate as to enable the operator to *lift the under one* with it, as if by its actual adhesion to the upper;—or if less closely applied, so that the thinnest possible layer of atmospheric air may still remain between, the upper plate will rest on the unexcluded particles, as if floating on quicksilver.

With similar devotion to accuracy Mr. Whitworth, in the search for a means of determining dimensions with precision, constructed a machine, so accurately and delicately made, as to measure objects which differ

detail by Mr. Whitworth in an article *on True Planes* in his *Miscellaneous Papers on Mechanical Subjects*, London, 1858. In it he shows that the former method of producing a level surface by grinding two plates of metal together with emery between, so far from producing a *true plane*, was in reality detrimental, inasmuch as the effect was to impart to one more or less of the imperfections inherent in the other, instead of correcting, as was supposed, the inequalities of both. 'Let it be supposed that one of the surfaces is concave, and the other a true plane; the tendency of grinding will, no doubt, be to reduce the error of the former, but the opposite error will at the same time be, to a certain extent, created in the opposite surface. The only possible case in which an original error could be extirpated in both would be when it was met by an opposite error of exactly the same amount, and the one destroyed the other. . . . . . It thus appears that the practice of "grinding" has impeded the progress of improvement, and that a *true surface*, instead of being in common use, is almost unknown.' (This had reference to the state of things existing in 1840.) To attain the desired object, Mr. Whitworth proceeds to show that it is necessary to make *three* planes in order to insure the perfect evenness of *one*, and that after imparting the utmost perfection attainable by means of a planing machine, each must be finished by hand, the operator using an instrument for removing by *scraping* every minute inequality, detected by rubbing each in succession on the surface of the other two. 'As the surfaces approach perfection the utmost caution and vigilance is indispensable to prevent them from degenerating, which will inevitably happen unless the comparison be constantly made *between them all*,' pp. 3, 19, 41.

even by the *millionth* part of an inch—a division so minute as to be perceptible only by *touch*[1] after it has ceased to be discernible by the eye. So nice is the adjustment, that in using it an inch of steel can be held to be an inch, only so long as the thermometer stands at 62°, the slightest excess of temperature producing an appreciable elongation;—and the standard yard, a square bar of steel, when placed in the machine is so *expanded by the slightest touch of the finger as to show an appreciable lengthening even under the influence of the infinitesimal amount of heat thus imparted.*

It might be supposed that the value of measures so minute must be but abstract and visionary, and that it could be only in the larger quantities that their use might be available. In practice, however, the import-

[1] In illustration of the extremely minute quantity represented by the *millionth* part of an inch, Mr. WHITWORTH explained to the *Committee of the House of Lords on the Weights and Measures Bill*, in 1855, that 'you have only to *rub* a piece of soft steel a very few times to diminish its thickness a millionth of an inch.' (*Report*, &c. p. 5.) Elsewhere he has stated that 'The principle of his measuring machine is the employing of the sense of *touch* instead of that of *sight*. If an object be placed between two parallel true planes, adjusted so that the hand can just feel them in contact, you will find on moving the planes only the *fifty-thousandth of an inch* nearer together, that the object becomes distinctly tighter, and requires greater force to move it between them. In the measuring machine (of Mr. Whitworth) a thin flat piece of steel (called the *gravity-piece*), having its two sides perfect planes, is introduced between the object to be measured and one of the end surfaces of the machine, so as just to allow it when raised by the finger to fall again by the force of its own gravity. But by bringing the two planes into closer contact, *by even the one-millionth of an inch*, this test-piece will be fixed and suspended, friction overcoming its gravity.' —WHITWORTH'S *Miscellaneous Papers on Mechanical Subjects*, p. 43.

ance of aiming at such accuracy has been visibly demonstrated. The former habit of being contented with approximate measurements engendered a positive inability to duly estimate superior correctness; and mechanics became accustomed to look on considerable variations in size, often productive of serious mischief, as not only venial, but even as a result of necessity. But like the Sybarite, whose sleep was disturbed by the inequality of his couch, occasioned by a ruffled rose-leaf,[1] Mr. Whitworth was impatient of even infinitesimal inexactitudes; and has accustomed the men in his employment to work to the 20,000th part of an inch, till measures so diminutive have become as familiar as those of larger dimensions.[2] In the most celebrated workshops in England thirty years ago, mechanics were chary of criticising work which was 'out' by the 32nd part of an inch, whereas in his works an error of 'division,' is at once noticed and corrected, a division being the 10,000th part of an inch.[3] The influence of these improvements in mechanical means has imparted a distinctive character of accuracy to the machinery of the United Kingdom, which places

[1] 'Idem sæpe questus est quod foliis rosæ duplicatis incubuisset.' SENECA *de Ira*, ii. 25.

[2] WHITWORTH'S *Miscellaneous Papers on Mechanical Subjects*, p. 58.

[3] *Report of the Committee of the House of Lords on the Weights and Measures Bill*, 1855, p. 4. This improvement has spread to other establishments also. Mr. ANDERSON, the superintendent of the government factory for artillery at Woolwich, stated in a discussion at the Institute of Civil Engineers, in February 1860, 'that in olden times there was difficulty in working to the $\frac{1}{16}$ of an inch, but the $\frac{1}{1000}$ of an inch was now measured with as much ease as was formerly the case with the $\frac{1}{16}$ or $\frac{1}{32}$ of an inch.'—*Proceedings, &c.* p. 71.

it in advance of all other countries; and to this nothing has more signally contributed than the standard gauges, graduated to a fixed scale as constant measures of size, for which practical engineers are indebted to the studious labours of Mr. Whitworth.[1]

It is not surprising that, in a profession so based upon accuracy as that of mechanical engineering, these achievements of Mr. Whitworth should have entitled him to the confidence of his cotemporaries, and attracted the attention of the government at the crisis when Lord Hardinge applied to him for assistance in May 1854. Even then the nature of the difficulty for the removal of which the military authorities were desirous of his advice and coopera-

[1] Another achievement of Mr. Whitworth, which has rendered signal service in conducing to uniformity and economy, not only in machinery, but in almost every complex object produced by it, is the perfecting of a system of screws, graduated to all sizes in actual use; the threads of each being adapted in pitch, depth, and form, to ensure the utmost possible degree of power, strength, and durability. The attention of Clement was given to a similar object, but it was reserved for Mr. Whitworth to achieve it. His system has now been adopted throughout almost every country in the world in which engines and machinery are either employed or manufactured; and taps and dies for producing the whole series are furnished from his works at Manchester. The value of this single reform may be conjectured when it is borne in mind, that before his time every engineer and machine-maker provided his own screws, on no preconceived principle, but of the most arbitrary form and the utmost variety of dimensions. The consequence of this divergence was the utmost confusion, delay, and expense in repairs, if done by any other individual than the actual maker; and a new screw having to be cut on every emergency, the waste of bolts and nuts was extreme and unavoidable. At the present time the same sets of screw-making tackle being to be found in every workshop in Europe, a damaged screw can be replaced by a new one with little more delay than is necessary to ascertain its number.

tion were imperfectly understood, and instead of instituting an enquiry to ascertain how far the imperfections which manifested themselves in the Enfield rifle were referable to errors *in the gun itself*, they were hastily attributed to some mysterious deficiencies in the *apparatus* by which the gun was made, and these it was sought to overcome by substituting the self-acting machinery of Mr. Whitworth, the higher accuracy of which would, it was hoped, produce the rifle in the numbers required without defect or variation.

But an obstacle presented itself on the threshold. *Mr. Whitworth was not a gun-maker,* and he had no more practical knowledge of the specialities of a rifle, or of the theories on which its excellence is dependent, than is possessed by any other highly educated engineer.[1] He had, however, in the course of a visit to America the year before, as Commissioner to the New

[1] *Evidence of the House of Commons Committee on Ordnance*, 1863. 1337.

'Mr. Whitworth was engaged in manufacturing instruments of peace when he was applied to by the Government. It was not his wish to enter upon the manufacture of these rifles; but having been applied to by the Government, he gave his skill, and energy, and devoted thousands of pounds of his own private fortune to carry on experiments which were first originated at the instance of the Government. Mr. Whitworth had no desire to make a fortune by the manufacture of rifles, but he had a desire to benefit his country by the production of the best weapon that could be manufactured for its defence, and to bring his skill to bear in producing an arm which should enable the troops of this country to meet the enemy, both at home and abroad, with effect. (Hear.) He ended by producing the very best weapon ever invented. That was the only honour he sought, and the summit of his ambition, and he has attained it, although, as I observed, very scant justice has been done to Mr. Whitworth since he completed his experiments.' (Hear.) — *Speech of* Mr. Turner, M.P., House of Commons, June 25, 1861.

York Exhibition, inspected the state armoury at Springfield, in Massachusetts; and it was chiefly in consequence of the opinion expressed by him of the suitability of the machinery which he there saw for the manufacture of fire-arms, that the attention of the British government was directed to its introduction at Enfield: but practically he was utterly unskilled in the process of making a rifle, and he felt it inconsistent with his reputation to make machinery for the multiplication of an imperfect article on the vague chance of correcting errors, the precise nature of which had not yet been discerned. Regarded from no loftier point of view, than as an order in the course of trade, the proposal made by the government that Mr. Whitworth should furnish designs for a complete set of new machinery for the Enfield establishment, was one of great pecuniary value. It would not have been difficult for him to have undertaken to supply the machines required, adapting those of known construction and making the necessary modifications suggested by himself; and it is manifest that the simple execution of such a commission on the terms proposed would have been of great commercial profit to his firm. But actuated by a higher motive, he did not feel himself justified in complying with the request; and in explanation of his scruples, he 'urged,' says Lord Hardinge, 'the importance of ascertaining what the first principle of this *unknown secret* is, before any machine could be constructed, to make a rifle that shall require no farther alteration.' [1]

[1] Lord Hardinge's *Memorandum*, May 17, 1854.

It was next proposed to him to undertake the construction of machinery for producing the rifle-barrel only; but to *the barrel*, above all others, his objection more especially applied; and in the absence of the requisite knowledge, he stated frankly that before giving an answer he wished to visit the establishments of the principal gun-makers in London and Birmingham, and to obtain from them all the information he could collect. 'I found,' he says in a report to the Secretary for War, 'great difference of opinion among them, and the statements I received were so contradictory, that I was unable to come to any satisfactory conclusion.'[1] The truth was that the gun trade generally in England at that time was described in the House of Commons as being in 'a rude and unsystematic' condition. The most skilful mechanics engaged in it worked by 'knack' rather than by system, and the making of two rifles of equal excellence was almost entirely dependent on the dexterity of the mechanic, who had no defined laws for reproducing them alike. It is only just, however, to men of such eminence as many of those engaged in that trade to state that this adherence to working by hand instead of by machinery was almost a compulsion of the period; since the demand was too limited to justify the erection of apparatus so costly as that which would have been required to supersede hand labour.

In this dilemma Mr. Whitworth, instead of grasping

[1] Mr. Whitworth's *Report to Lord Panmure, Secretary of State for War*, June 13, 1857.

at the order for new machinery for Enfield, offered to the Board of Ordnance to conduct a preliminary series of scientific experiments in order to determine the true principle on which rifle barrels ought to be constructed; provided a shooting gallery was erected for him near Manchester, under his own direction, in which to carry on the necessary trials, and thus obtain data for his guidance. The actual expense was of course to be defrayed by the Treasury; but he intimated his readiness to devote his time and attention to the subject *gratuitously*, actuated only by the interest with which it had inspired him. The gallery, he said, must be enclosed, in order to insure the protection of the experiments from the influence of winds, and other disturbing causes. In it he proposed to commence a series of trials with the most accurately made rifles which could then be produced. To those which proved the best he would apply certain tests, to determine the precise form of the barrels, and arrive at the knowledge of the particulars in which they severally excelled, and of the sources to which that excellence was due; and thus, by combining results, he hoped to ascertain the conditions required for producing the most perfect instrument. The information so acquired was to be at the service of the government, to whom, in order to facilitate manufacture, he would supply graduated gauges, with directions for their use. For eventual success in constructing machinery to produce and reproduce rifles giving the greatest possible range

and accuracy without the minutest variance in excellence and quality, he had the firmest reliance, not on speculative theories, but on the teachings of experience, derived from his accomplishment of the two great mechanical desiderata—'the production of *true surfaces* and perfectly straight lines, and the power of making *measurements* with any required exactitude even to the millionth part of an inch.'[1]

This disinterested offer was not at first accepted. The military authorities were not favourable to Mr. Whitworth's proposal for undertaking the experiments,[2] and the subject remained for some time in abeyance, till revived by the interposition of the Earl of Ellesmere, at whose instance Lord Hardinge, then Commander-in-Chief, gave his earnest support to the offer, and brought before the Treasury the necessity of immediate compliance. Lord Hardinge strongly represented the urgency of providing machinery to insure not only a rapid supply of arms, but one of uniform quality; and he dwelt on the primary importance, before commencing its construction, of determining on what principle its excellence depends, instead of beginning blindly an expenditure which, looking to the number of muskets required, could not be less than *two millions sterling*. As regarded

[1] Mr. WHITWORTH's *Letter to Lord Raglan*, Master-General of the Ordnance, April 3, 1854.

[2] Colonel CHALMERS, in his letter to Lord RAGLAN, April 15, 1854, reported that the Committee on the Small Arms Factory, to whom Mr. WHITWORTH's proposal had been referred, were 'of opinion that it is not at present desirable to commence a series of expensive experiments such as Mr. WHITWORTH has suggested.'

the machinery itself, he said, 'the most celebrated mechanician of his country, Mr. Whitworth, had declined the responsibility of producing it until he had first, by the most careful experiments, ascertained the true principle for constructing and rifling the barrel. So essential did he consider this precaution, that Mr. Whitworth would rather defray the attendant expenses himself than proceed without preliminary investigation.'[1] The government, Lord Hardinge said, wanted at the earliest possible moment a million of muskets, which Birmingham could not supply under the existing system in less than *twenty years*. In fact, they could only be produced by machinery, as 'no gun-smith could imitate the most perfect rifle, nor does he know *why* it shoots well or ill; but if the secret be discovered, it may be copied by machinery, and Mr. Whitworth is very confident that he *can* discover and can copy it.' Lord Hardinge concluded by saying that he 'foresaw that if this necessary demand of Mr. Whitworth be denied *there would be an end of the plan of making rifle barrels by machinery*.'

The assent of the Lords of the Treasury was signified in May 1854, and a gallery 500 yards in length by 16 feet broad 20 feet high was forthwith commenced in the grounds attached to Mr. Whitworth's residence, near Manchester. This was provided with a target on wheels for shooting at varying distances, rests for steadying the aim, and screens to exhibit the flight of the projectiles. Two military officers were nominated

[1] Lord HARDINGE *to the Treasury*, May 17, 1854.

by the Commander-in-Chief to assist at the experiments, and Mr. Westley Richards was associated with Mr. Whitworth at the request of the latter, who was desirous of benefiting by the information and experience of a gun-maker of his high reputation.

CHAPTER III.

THE 'SECRET' DISCOVERED.—THE WHITWORTH RIFLE.

ON October 13, 1854, Mr. Whitworth reported to the Secretary of the Board of Ordnance the completion of the gallery, on the successful use of which Lord Hardinge relied for the disclosure of what he had described as that 'unknown secret,'[1] the application of which was to dispel the uncertainty that had so long obscured the search for a weapon worthy of the army of Great Britain. But operations were delayed by a sudden calamity:—within a week after the completion of the edifice, the greater portion of it was laid in ruins by a storm of extraordinary violence which swept over that part of England. It was not till the spring of the following year that it could be restored; and experiments with the rifle were only commenced in March 1855.

The interval which elapsed was occupied in investigations for improving the construction of heavy ordnance. The feelings of the country at that moment had been harrowed by heart-rending accounts of the sufferings of the army in the Crimea, and amongst

[1] See Lord HARDINGE's *Memorandum*, May 17, 1859.

others of the painful exertions required to move large siege-guns from the beach at Balaclava into position on the heights before Sebastopol. This is a branch of the subject which will be more fully noticed hereafter, meanwhile it is only necessary to state, that there being at that time no intention to discontinue the use of cast-iron as a material for ordnance, Mr. Whitworth's object was to devise the best form in which its properties rendered it capable of being employed. For this purpose, it occurred to him to construct a rifled cannon, cast in longitudinal segments, in each of which the line of junction was to follow the course of the spiral. These, when placed together so as to form a barrel of a spiral polygonal shape internally, were to be secured externally by hoops of wrought-iron or steel,[1] applied in one or more layers.

From the barrel thus rifled, a model about thirteen inches long, but made to musket size as regards the bore,[2] was found to shoot with such accuracy, as to excel all others tried in competition with it. The project of making artillery on this plan was not prosecuted further at that moment, the pressing motive having passed away; but the idea of a *polygon* thus originally taken up by Mr. Whitworth for rifling artillery, he afterwards adopted for arms of all sizes, from the musket to the heaviest guns.

In commencing operations with the soldier's rifle in

[1] Mr. WHITWORTH's *Letter to* Lord PANMURE, June 13, 1857, and his evidence before the House of Commons' Committee on Ordnance, 1863, p. 105, quest. 2446, &c.

[2] *Evidence, &c.*, 1288, *&c.*

the new gallery, Mr. Whitworth found himself subject to a conventional limitation as to the range of his experiments, imposed by the special nature of their object. That object being ostensibly to discover the true principle for the construction of a fire-arm for infantry—and Government having previously fixed the weight of the musket, including its charge, and its projectile, which (together with the usual number of rounds of ammunition) a soldier could carry with ease, and discharge without suffering from the recoil—it was to the discovery of improvement within these conditions that he was first to direct his attention.

1. *The best form of Projectile.* On addressing himself to this new pursuit his attention appears to have been directed, in the first instance, to determine the form of *projectile* best adapted at once for flight and precision. The superior advantage of the conical over the spherical ball had been long before demonstrated,[1] in the increased range and augmented power of penetration realised by diminishing the diameter, and thus reducing atmospheric resistance. But in all his early attempts to take advantage of this property by increasing the elongation, he was baffled by finding that a ball greatly exceeding the length usually fired from the Enfield, or any other musket with a slow turn of rifling, instead of maintaining a flight parallel to its axis, invariably capsized, or, as it is technically said, '*turned over*' on leaving the muzzle of the gun.[2] An arrow

[1] Sir Howard Douglas on *Naval Gunnery*, p. 72.

[2] 'The steadying effect of a rotation round the line of motion is

from a bow would do the same, were not means taken to ensure its flight in a line with the barbed end by fledging the opposite extremity with a feather. On the same principle he endeavoured to correct the errant tendency in his 'bolt' by various devices for so adjusting the centre of gravity towards the front as to ensure its uniform advance in the direction of the object aimed at. With this view he employed metals and combinations of metals of different densities; but no change of shape, and no re-distribution of weight, was sufficient to enable him to use a ball of any greatly increased length; one and all they continued to 'turn over,' as was rendered apparent by the marks left by each on passing through paper screens placed near the gun.

Having exhausted every resource applicable to the projectile in ineffectual endeavours to overcome this inherent difficulty, he became convinced that the defect was ascribable to *the piece* not less than to the projectile, and that it was in fact attributable to the *inadequate rotation* incident to the system of slow rifling which obtained at that period. In the Enfield musket, with which his first abortive trials were made, the twist or spiral rifling curve takes but one turn

plainly seen in a common shuttlecock, which flies quite wild unless it twist briskly round its axis. In like manner there is great nicety in putting on the feathers of an arrow. They should be so placed, that in looking along any of them the point of the arrow should appear about half an inch to the left hand of the direction of the feather. Such an arrow, let fall, will sensibly turn round its axis. If it turn briskly the feathers are too oblique, and will impede its progressive motion; but it will fly more true.'—ROBISON'S *Mechanical Philosophy*, vol. i. p. 203.

round the interior of barrel in 78 inches. A shorter rifle made by Mr. Whitworth, with one turn in 60 inches, gave better results, but proved still unsatisfactory. Another, with one in 30 inches, exhibited further improvement; but eventually, after testing every gradation, between 78 inches and 5, one in which the turn was *one in every* 20 *inches* (being nearly four times that of the military rifle), was found to yield the best average result, and thus solved the problem; this increase of rotation sufficing to impart the required steadiness to the flight of the ball. It no longer capsized, but, on the contrary, maintained a continuous flight in a path duly parallel to its axis.

Such confidence did he feel in the soundness of the principle thus successfully developed, that in his report of progress made to the Secretary for War in 1857, he declared his ascertained ability, by means of a system of polygonal rifling with a quick turn (which will presently be adverted to) to communicate such velocity of rotation as effectually to control the tendency to 'turn over' in projectiles of *any length that might be required.*

For ordinary service, however, the projectile which he has adopted, as most suitable for small arms, is a ball of a cylindro-conoidal form or shaped hexagonally, with rounded corners to fit the angles of the bore, with a conical front, and a *length of three, or three and a half times its own diameter.*

No demonstration could more clearly exhibit the correctness of the theory on which all rifling depends. To

use a familiar illustration, a top, when spun, maintains its vertical position in defiance of the laws of gravity; because the velocity of its revolutions suffices to counteract the disturbing effect of inequality in its various particles and proportions, and to bring all into practical equilibrium. In like manner a bullet discharged from a rifle, provided it be endued with sufficient velocity of rotation, has all its inequalities so equally distributed around its axis as to enable it to pursue an even flight in the direction in which it is fired.

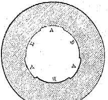
But in the effort to maintain this steady advance, a ball when discharged has to contend with other difficulties besides those occasioned by its own inequalities, either of consistency or of configuration. Were it possible in practice, as it is imaginable in theory, to cast a spherical bullet so perfect in form that all points of its circumference would be equal radii from its centre, and so uniform in density that no one particle should exceed the gravity of any other; still the probability is that it would exhibit an irregular flight, either from the influence of windage in the gun, the want of true lines in the barrel, or even the possibly unequal action of the forces engendered by the explosion of the powder.

To subdue and equalise these disturbing influences, resort is had to the *rotation* communicated by rifling; and this is capable of being raised to a degree equalling and even exceeding [1] the forward velocity of the bullet.

[1] With a view of ascertaining the degree of penetration, when the rifling is carried to an extreme, Mr. Whitworth made a rifled barrel

'In some projectiles which I employ,' says Mr. Whitworth, 'the rotations are 60,000 a minute. In the motion of machinery 8,000 revolutions in a minute is extremely high; and considering the *vis viva* imparted to a projectile as represented by a velocity of rotation of 60,000 revolutions, and the velocity of progress of 60,000 feet per minute, the mind will be prepared to understand how the resistance of thick armour plates of iron is overcome, *when such enormous velocities are brought to a sudden stand still!*'[1]

2. *The proper system of Rifling.* The proper form of projectile having thus been established,[2] as well as the essential importance of high rotation, the next point to be determined was the *system of rifling* best adapted to both. As stated above, Mr. Whitworth, for convenience of manufacture and other considerations having been led to adopt the polygonal form for large guns, applied it on analogous grounds to rifled small-arms. The custom previously had been to excavate '*grooves*' out of the substance of the barrel, at convenient distances leaving untouched



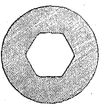
SECTION OF THE ENFIELD RIFLE.

twenty inches in length, giving twenty turns to the rifling, or *one in every inch;* so that the *velocity of rotation at the surface greatly exceeded that of progression.* In firing it drove a bullet, composed of lead and tin, through seven inches of elm.

[1] WHITWORTH'S *Miscellaneous Papers on Mechanical Subjects*, p. 4.

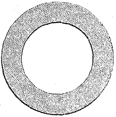
[2] See a figure of the ball for the Whitworth rifle at p. 48.

certain portions technically denominated '*lands*.' In the Enfield musket, for example, the number of 'grooves' A A A was three,[1] and three 'lands' B B B. Instead of this, he converted the entire inner surface of the barrel into something approaching a hexagon; leaving in the middle of each division of the plane surface a small curved portion, coincident with the original circular bore of the gun; and rounding the angles, to contribute to the strength of the barrel.[2]



SECTION OF THE WHITWORTH RIFLE.

Amongst the advantages incident to hexagonal rifling, allusion has been made above to 'convenience of manufacture.' The import of this will be apparent when it is borne in mind, that in the process of making a gun barrel, a *tube with a smooth cylindrical bore* is the simplest of all figures to construct, and its projectile, being spherical, is the most economical to make. But besides the circumstance that that form is incapable of imparting to the



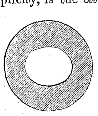
SMOOTH BORE FOR A SPHERICAL PROJECTILE OF 530 GRAINS.

[1] In some of the Enfield rifles the number of grooves has since been increased from *three* to *five*; and as the width of each groove is the same, the addition has served to diminish the breadth of the lands.

[2] It will thus be seen that although the basis of the figure is a hexagon, the term 'hexagonal,' popularly accepted for the Whitworth *rifle*, is not strictly correct. That figure is slightly departed from to make the form thus adopted more practically efficient, but still the term 'hexagonal' is sufficiently precise for ordinary description.

ball the rotation produced by rifling, the charge of powder necessary to propel a ball of a given weight for a given distance from a smooth bore is greater than that required in the rifle.

Nearest to the circular bore in geometrical simplicity, is the *ellipse* adopted by Mr. Lancaster for his rifled cannon;[1] but the manufacture becomes complicated by the difficulty of making the oval cutters used in rifling the barrel, as well as in restoring them when worn or out of order, without deviation from the original line.



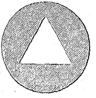
OVAL RIFLE-BORE FOR AN ELONGATED PROJECTILE OF 530 GRAINS.

A practical mechanic would consider the form of rifling most eligible to be one composed of right lines; since these can be produced by a cutter with a straight edge, easily made and susceptible of equally easy repair. But in a triangle, which is the simplest combination of straight lines, in addition to other adverse considerations, the area would be too small in relation to the circumscribing dimensions; besides which, both in a 'trigon' and in a 'square,' there would be such an unequal distribution of strength throughout the barrel as would be inconsistent with its safety.

Both objections are removed by cutting off the sharp corners, thereby doubling the numbers of angles, and increasing their obtuseness, so as to present a closer relation between the internal outline of the bore and

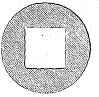
[1] In the annexed diagram the ellipse is slightly exaggerated.

the external circumference of the barrel. The square so treated becomes an octagon, which some gun-makers prefer; but, according to Mr. Whitworth, a better medium is obtained by converting the triangle into a *hexagon*, by amputating its extremities, and thus obtaining the required area, with an adequate distribution of strength.



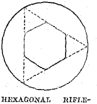
TRIANGULAR RIFLE-BORE FOR A PROJECTILE OF 530 GRAINS.

Essential as these considerations are even in relation to small arms, in the manufacture of which such facilities exist for the treatment of metal with a view to the control of power and the absolute security of the piece, they become infinitely more important in the case of artillery; where the force employed is so stupendous, and the difficulty proportionally great of providing against the destruction of the gun. Of this I shall have occasion to speak presently.



SQUARE RIFLE-BORE FOR A PROJECTILE OF 530 GRAINS.

But limiting attention to simplicity of construction and consequent economy of cost, rifling of this character formed by a few straight lines has a manifest advantage over those which consist only of curves, or of curves combined with other figures, and even over a multiplicity of angular grooves.



HEXAGONAL RIFLE-BORE FOR A PROJECTILE OF 530 GRAINS.

Meanwhile as regards both muskets and heavy ordnance, it will be obvious that polygonal rifling, in addition to all other points of superiority, has the advantage of admitting a projectile externally of the same shape, to fit the internal bore of the gun; and this projectile may be made of steel or any other metal, soft or hard. At the same time the piece is equally adapted for firing an expanding bullet of lead, which during the explosion fills up the angles; so that the entire 'upset' is made so conducive to rotation that in firing these cylindrical projectiles the Whitworth rifle has given much better practice than the Enfield, although the latter was specially designed for them. As regards steadiness of flight, the new system displayed a like superiority over the old, in which the compressed bullet evinced more or less eccentricity;[1] whilst the Whitworth bullet duly fitted to the hexagonal barrel issues from the muzzle in a line concentric with the bore; and hence the marvellous precision exhibited in all its comparative trials against rifles of the most skilful competitors.

Another advantage claimed for polygonal rifling over that with grooves is the greater service and longer

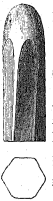
[1] May not one cause of this eccentricity in the old Enfield ball be more or less ascribable to the fact that it contained no provision for ensuring the equable expansion of the lead by the *uniformly concentric* entrance of the plug in the rear, which might on the contrary take an irregular direction during the explosion, and thus give rise to an inequality of density, for which its low power of rotation afforded no sufficient correction? Contrasted with this, the Whitworth projectile presents *the elements of superiority in the precise* fitness of its form, as well as the homogeneity of its metal.

duration of the barrel both in rifles and in cannons. In the former the projectile, in its progress toward the muzzle, is guided evenly by the sides of the barrel, which all act upon it uniformly in imparting rotation; whilst in the latter the bullet is conducted by the edges of the grooves only, so that a very small extent of the surface of the barrel acts in contact with it. But that small portion has to sustain all the wear caused by the friction; and the barrels being made of soft iron, it is not surprising that rifles so soon wear out; and that those used in the British army have, it is said, to be replaced after twelve years' service. The Whitworth rifle, on the contrary, being made of homogeneous metal, which is a mild kind of steel, has a greatly prolonged endurance; which, combined with its peculiar form of rifling, renders it more economical. Nor is the accuracy and care required in its construction more costly than ought to be applied in the production of any other gun intended to shoot correctly.[1] Besides, it does not involve anything beyond ordinary care in handling and using it; on the contrary, the ease

[1] With the view to improving the old system of measuring gun-barrels, Mr. Whitworth made about this time a series of cylinders called 'difference gauges,' in sizes differing by the $\frac{1}{5000}$th of an inch, five being less and five greater than the standard size of the Government bore, ·577 in. Some considerable time elapsed before these gauges were employed in the Enfield works; but a set having been supplied to Mr. Westley Richards, that gentleman stated that he was thereby enabled to improve the shooting of rifles to which they were applied from 50 to 100 per cent. He used them in manufacturing four rifles which were fired in comparison with four Enfields specially sent for the occasion, when the average deviation of the shots from the centre of the target was 12·56 and 38·40 respectively.

with which the bullet is introduced affords the greatest facility in loading.

At the commencement of his practice Mr. Whitworth found that a cylindrical leaden bullet expands so readily into the rounded corners of the hexagon that all apprehension was removed of what is technically called 'stripping,' whereby the bullet, instead of following the spiral turn of the rifling, impinges against its edges and divesting itself of form issues from the barrel without rotation. It was even less possible for such an occurrence to take place, with the mechanically fitting projectiles which have a configuration conformable to the hexagonal outline of the bore. Bullets so shaped can be made of iron or steel; but for general use those of lead were adopted, hardened by a due alloy of tin. So far were these from 'stripping' or running into the opposite extreme of 'jamming,' to the injury of the piece, that distortion was avoided, the flight was rendered more true, the trajectory lowered, and the power of penetration was augmented, the whole explosive force of the powder being exerted in propelling the projectile; whereas in the case of cylindrical projectiles part is absorbed in expanding the bullet, part escapes before this is accomplished, and the balance alone is left for propulsion. One of these bullets composed *one-tenth* of tin and nine-tenths of lead, fired at 50 yards, with a charge of $2\frac{1}{2}$ drachms of powder, passed through fifteen inches



BULLET FOR THE WHITWORTH RIFLE.

of elm, whilst under equal conditions a conical bullet of lead fired from the Enfield rifle penetrated only through *six*.

Another point of uncertainty which required to be determined was, whether the greatly increased rapidity of rotation imparted to the projectile might not possibly interfere with its trajectory,[1] and prejudice its faculty for horizontal flight. To determine what loss (if any) was to be apprehended from this source, Mr. Whitworth made a barrel 39 inches long with what he considered at that time an unusually quick turn of *one* in 10 inches, which gave nearly four turns in the barrel instead of the *half* turn of the Enfield rifle. Relying with confidence on the mechanical fit of the ball, he had no fear of its 'stripping,' and on trying it he found that the increase in the quickness of the turn produced no appreciable increase in the arch of the trajectory. Many subsequent experiments with barrels having turns even *more* quick, proved beyond all doubt that the requisite amount of rotation could be given to projectiles without a sacrifice of direct horizontal range, force being utilised at the same time by preventing the too ready escape of the bullet.

The principle of polygonal rifling was not new, nor did Mr. Whitworth lay any claim to originality in its conception. Its application to guns had been attempted by others before him, and a rifle is exhibited in the arsenal at Woolwich hexagonally bored by Serjeant

[1] *Letter to* Lord PANMURE, June 13, 1857.

Moore of the Royal Artillery, so far back as 1839. But it is not the abstract idea that constitutes the real question in the majority of those cases which give rise to disputes about priority of invention: the 'principle' may be common to all, but the merit of discovery attaches to its practical application in new combinations and under new forms. It no more qualifies the honour due to Mr. Whitworth as the inventor of his own system, that polygonal rifling had been previously thought of, than it militates against the merit of Mr. Nasmyth, that a patent for a steam-hammer had been taken out by Devereux in 1804. The idea of polygonal rifling occurred to the late Mr. Brunel in 1852 (but others, he states, had preceded *him*), and two experimental rifles were made for him[1] at Birmingham, by Mr. Westley Richards. But independently of minor differences between them—such as the use of an octagon instead of the Whitworth form, the retention of the angular corners, and the introduction of an 'increasing'[2] instead of a uniform pitch in the rifling—the system introduced and patented by Mr. Whitworth in 1854 (before commencing his official experiments in the new gallery), and again in 1855, presented this distinctive claim to originality, that it was the first which, along with a peculiar form

[1] See Mr. Brunel's *Letter* to Mr. Westley Richards, Nov. 26, 1858, in the Appendix to the *Report of the House of Commons' Committee on Ordnance*, 1863, p. 402. See also the evidence of Mr. Westley Richards, p. 191, etc., and that of Mr. Whitworth. *Ibid.* p. 110, 112.

[2] See *post*, p. 54.

for rifling, included the use of a *corresponding form for the projectile*. The system is one which seemed naturally to suggest itself to the constructive minds engaged upon the rifle, as affording the best means for working out the two fundamental yet simple principles of practical mechanics embodied in the production of *true plane* and the power of *accurate measurement*. Its adoption by Mr. Whitworth occurred, as has been already stated, when he was engaged in the considera-tion of the best mode for constructing siege-guns, with a view at once to strength and portability; and by him it was afterwards applied, and brought to its ulti-mate development in the production of the rifled musket.

The 'unknown secret' which had so long been a desideratum with the Ordnance department was thus disclosed; and the principle was found to consist in an *improved system of rifling*; *a turn in the spiral four times greater than the Enfield rifle; a bore in diameter one-fifth less; an elongated projectile capa-ble of a mechanical fit*; and last, but not least, *a more refined process of manufacture*.

Like many other theories which mechanical skill has reduced to practical realities, the idea of reduced bore and increased twist had occurred to one other experi-menter at least, before it was worked out and adopted by Mr. Whitworth. Both were recommended some years before by General Jacob of Indian service; who, when in command of the Scinde Irregular Horse, con-ducted, at his own expense, a series of experiments on

the rifle such as have seldom been undertaken even by the most enlightened governments. All suggested improvements were tested by him under every conceivable shape, and hundreds of thousands of experiments recorded and classified.[1]

The diameter of the bore, which in the Enfield musket is ·577 of an inch, was reduced in the Whitworth rifle to ·451 measured across the flats, or ·490 across the angles of the hexagon. The change was not made without due deliberation and data; Mr. Whitworth's experiments with various bores having shown that with each diameter there is a corresponding charge of powder, and a suitable weight of projectile, which with a given range will give the best trajectory, together with the least recoil. In the Enfield rifle, with a bullet of the regulation weight of 530 grains, he found that the bore of ·577 of an inch was *too large* for the charge employed, inasmuch as it gave too high a trajectory; and that any attempt to increase the charge, so as greatly to reduce the arc of the trajectory, would render the recoil so severe that soldiers would require to be much stronger than ordinary men, to endure it. Repeated trials served to satisfy him that on the whole a bore of ·451 in. was preferable, enabling 70 grains of

[1] *Edinburgh Review*, April 1859, p. 623. The result of General Jacob's researches was the production of a short-barrelled four-grooved rifle, 'with which,' to use his own words, 'a tolerably good shot can certainly strike an object the size of a man, once out of three times, at 1,000 yards distance; and of which the full effective range is about 2,000 yards, the ball at this range still flying with deadly velocity.' Captain Pelly's *Views and Opinions of* Brigadier General Jacob.

powder to propel a projectile of 530 grains, at a very low trajectory, and without inconvenient recoil; the trajectory of his rifle being *eight feet six inches* at its highest point, and that of the Enfield *eleven.*

Another point to be determined was the degree of twist to be given to rifling, and the number of turns requisite to impart the necessary velocity of rotation for ordinary service. In the Enfield musket, as already stated, the spiral curve to be traversed by the bullet makes *one* turn round the interior of the barrel in advancing *six feet and a half*; but this moderate degree admits only of the use of short projectiles, as long ones 'turn over' on issuing from the muzzle, and short ones become unsteady at great ranges. For all practical purposes Mr. Whitworth adopted with his reduced bore one turn in 20 inches, which he found to be ample for securing a comparatively steady flight over a range of 2,000 yards.

The advocates of the slower twist upheld it on the ground that anything quicker was liable to impede the ball by producing friction to an injurious if not dangerous extent; but in the course of his experiments Mr. Whitworth demonstrated that the effect of *great* rapidity is felt, not at the breech when the ball is beginning to move, but towards the muzzle when it has acquired its maximum of velocity; — and that 'whatever strain is put upon a gun at the instant of explosion is due, not to the resistance of friction, but to the *vis inertiæ* of the projectile which has to be overcome at starting, and is, of course, greater as the projectile is made more

heavy.'[1] It is owing to this *vis inertiæ* that the portion of a gun, whether of small or great calibre, which most of all requires strength and resistance, and which most frequently gives way during service, is the region of the breech in front of what is commonly known as the chamber for the powder.

This fact is in itself conclusive against the adoption of a plan, that has occasionally been entertained, of rifling with an '*increasing pitch*'—that is, beginning with a comparatively slow spiral or rifling curve at first, the turns increasing in rapidity and number as the twist approaches the muzzle. This was conceived with the design to relieve the supposed friction at the moment when the ball commences to rotate; but the force required to cause a projectile to turn on its axis is so slight compared with that which is necessary to impart its direct momentum, that it may almost be omitted from consideration.[2] Besides which a projectile intended to be fired from a rifle with an increasing twist, must be made of soft metal to enable it to adapt its form to every successive change in the curve of the rifling, thus causing *increasing resistance*, which becomes greater as it reaches the muzzle, the very place where relief is wanted.

[1] WHITWORTH'S *Miscellaneous Papers on Mechanical Subjects*, p. 17.

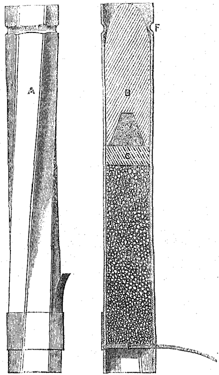
[2] Mr. BIDDER, the President of the Institute of Civil Engineers, found that the force sufficient to give rotation to a 3-lb. shot fired from a Whitworth rifled gun, compared with the force required to impart its forward motion, *was as* 1 *to* 170. Time, however, is an element which has to be taken into consideration, for the high rotation of upwards of 60,000 revolutions per minute has to be imparted almost instantaneously.

A further consideration, not of minor importance, remained to be provided for; the inconvenience arising from the tendency of gunpowder after explosion to leave deposits, more or less hardened, encrusting the inner surface of the barrel. To prevent this from accumulating, Mr. Whitworth inserted along with every charge a proper quantity of lubricating material, introduced as a 'wad,' which under the force and heat of explosion is distributed over the interior of the bore, rendering the fouling residuum so loose that it is driven out by the next discharge.[1] The most suitable composition he found to be a mixture of tallow and wax, and with this introduced between the powder and the ball a cartridge for the Whitworth rifled fowling-piece presents the appearances shown in the accompanying sketch. The powder, the wad, and the bullet, in the order which they are required to take in the barrel, are placed in a tubular case which is closed by a slip of paper that acts as a 'trap-valve.' This being withdrawn when the cartridge is placed in the muzzle, its contents, by one thrust of the ramrod, are sent home to the breech.

And here it may be well to repeat, that the principles

[1] Competitive trials of small-bore rifles are invited annually by the National Rifle Association, and it may be remembered that at the contest held at Woolwich in 1863 Mr. WHITWORTH introduced a new ramrod, which, by the action of a mechanically fitting head revolving on an axis, removes all fouling deposits. On that occasion the Regulations for the day rendered the use of this inadmissible; but after the contest riflemen generally hastened to adopt the new ramrod, which has proved to be a signal improvement.

thus disclosed and elaborated in the production of the Whitworth rifle are not limited to guns of small calibre.



CARTRIDGE FOR THE WHITWORTH RIFLED FOWLING-PIECE.

A. External view.
B. The ball.
C. Wad.
D. Charge of gunpowder.
E. Slip of paper, on withdrawing which the contents of the cartridge are forced by the ramrod into the barrel.
F. A groove, to admit securing the whole by a compressed tie.

They are 'applicable equally to ordnance of all sizes; and not only so, but the mechanical difficulties diminish with the expansion of the dimensions, and the advantages to be secured appear to increase with the increased proportions of the gun.'[1] It has already been seen[2] that the model of a cannon in segments exhibited *the germ of the Whitworth rifle*; and all the prodigious powers that have since been manifested in ponderous pieces of ordnance are but expanded developments of the one pervading principle which imparts its value to both.

As regards rifled guns for naval warfare, it was from *data* derived from his rifled musket that Mr. Whitworth ventured in 1857 to predict what he accomplished in 1860 and 1862. With a flat-fronted projectile of steel, fired from it with $2\frac{1}{2}$ drachms of powder at a distance of 20 yards, he succeeded, at an early period, in piercing through a plate of wrought iron six-tenths of an inch thick, upon which a spherical ball of the same metal, fired with the same charge of powder, made only a shallow indentation. Hence he confidently predicted, so early as June 1857, that '*projectiles of wrought iron steeled, might be made for pieces of ordnance, capable of penetrating the sides of floating batteries*'[3] protected by iron armour.

It is necessary here—in closing this brief narrative of

[1] Mr. WHITWORTH to Lord PANMURE, Secretary for War, June 13, 1857.

[2] See Chap. II. p. 37.

[3] Mr. WHITWORTH'S *Letter to* Lord PANMURE, June 13, 1857.

the rifled musket, and before commencing the story of the large gun—to anticipate the order of time, and to recapitulate summarily the events which have since occurred in relation to the Enfield and Whitworth muskets; between the year 1857, when the author of the latter reported its completion to the Secretary for War, and the present time.

The Whitworth rifle was first formally tried in competition with the best Enfield muskets at Hythe, in April 1857, in the presence of the Minister of War, and a large assemblage of the most experienced officers, including amongst others the Superintendent of the Enfield factory, and General Hay, the chief of the School of Musketry for the Army. The success was surprising; in range and precision it excelled the Government musket three to one. Up to that time the best figure of merit obtained by any rifle at home or abroad, was 27; that is to say, the best shooting had given an average of shots within a circle of *twenty-seven* inches mean radius, at 500 yards distance; but the Whitworth lodged an average of shots within a mean radius of *four inches and a half* from the same distance; thus obtaining a figure of merit of $4\frac{1}{2}$. At 800 yards its superiority was as 1 to 4, a proportion which it maintained at 1,000 yards and upwards. At 1,400 yards the Enfield shot so wildly that the record ceased to be kept; and at 1,800 yards the trials with it ceased altogether, whilst the Whitworth continued to exhibit its accuracy as before. The accompanying

Diagram of shooting by WHITWORTH'S RIFLE in 1857.

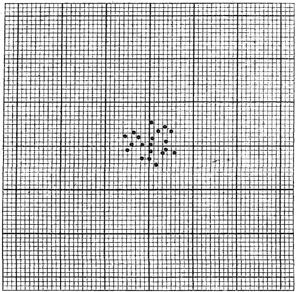


Figure of merit 4½ inches. Range 500 Yards, charge 70 grains, projectile 530 grains.

Diagram of shooting with the ENFIELD RIFLE in 1857.

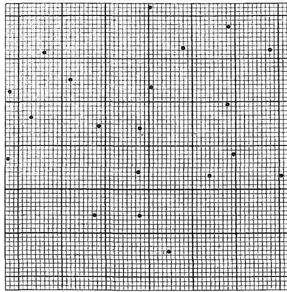


Figure of merit 27 inches. Range 500 Yards, charge 70 grains, projectile 530 grains.

Small squares = 1 inch.
Large squares = 10 inches.

H. Adlard Sc.

diagram serves to render the comparison apparent to the eye.[1]

A cotemporary writer summing up the results of these early trials says, at the time Mr. Whitworth commenced his experiments 'it was deemed first-rate workmanship in a rifle, if the deviation from accuracy in the barrel did not exceed 1 in 300; Mr. Whitworth reduced it to 1 in 10,000. In point of accuracy and range, the advantage of the old rifle over "Brown Bess" was more than *five* to *two*, the advantage of the Whitworth rifle is at *fifty* to *one* over the old rifle. Its combined improvements give a more correct range than the Minié, and one-half further with one-third less gunpowder. The extreme range of the Minié is 1,400 yards, but the

[1] The following Table exhibits the official return of results:—

Description of Rifle	Distance in Yards	Angle of Elevation	Mean Radial Deviation	Remarks
			feet	
Enfield . . .	500	1° 32′	2·24	
Whitworth . .	500	1 15	·37	
Enfield . . .	800	2 45	4·20	
Whitworth . .	800	2 22	1·00	
Enfield . . .	1,100	4 12	8·00	
Whitworth . .	1,100	3 8	2·62	
Enfield . . .	1,400	—	—	Shooting so wild no diagram taken
Whitworth . .	1,400	5 0	4·62	
Enfield . . .	1,800	—	—	Not tried
Whitworth . .	1,800	6 40	11·62	

The trials above alluded to took place from a fixed rest: the following day General HAY with a Whitworth rifle *fired from the shoulder*, and made a target of 15 inches at 800 yards; that is to say, from that range all his shot told within that mean distance of the centre. The range was then increased to 1,000 yards, when the practice he made was equally good.

range of the Whitworth is 2,000. On careful trials at 500 yards' distance, the accuracy of shooting of the English Whitworth is more than ten to one compared with the best French Miniés now made.' [1] This allusion to the Miniés refers to the competitive trials at Vincennes in 1860, when the Whitworth rifle was ordered by the Emperor to be tried against the best pieces that France could then produce. At a range of 500 mètres the former was victorious in the proportion of *three to one*; at 700 mètres the French retired from the contest; while up to 1,000 the Whitworth continued to make accurate shooting.

As a consequence of the trial at Hythe in 1857, an official committee was appointed, composed partly of military officers and partly of officials, more or less associated with the introduction and manufacture of the Government rifle at Enfield,—Mr. Whitworth was also nominated as a member. After eighteen months spent in desultory discussions and experiments, this Committee made a report, in which only a section of the members concurred, whilst others recorded their individual opinions in protests; and the committee eventually separated without recording any consistent recommendation sufficient for the guidance of the Secretary at War.

Although the superior merits of the Whitworth rifle were admitted throughout the minutes of their proceedings, the making of the Enfield musket continued with unabated assiduity. But experimentally,

[1] *The Spectator*, October 1860.

important improvements have since been adopted in what was called the 'small-bore Enfield,' which has not yet been taken into the service. In it the calibre has been reduced from 0·577 to 0·451 of an inch, whilst the rapidity of rifling has been augmented from one turn in 78 inches to one in 20. The original system of grooving has been retained, but with the view of easing the friction on the lands, the number of grooves has been increased from three in the service musket to five in the 'small bore.' Both in the *reduced diameter* of the bore therefore, and the *increased rapidity of the rifling*, these features have been adopted from the Whitworth model; and though many previous defects have been corrected by the change, others remain, so that the Whitworth maintains its original superiority over both service and Enfield 'small bore.' Nor is there any apparent reason why a bore equal to that of the service musket, rifled on the Whitworth system, should not be made to surpass it both in range, penetration, and accuracy of fire.

The Chief of the Government School of Musketry at Hythe, General Hay, than whom from his official responsibilities no authority could be more impartial, when called on in February 1860, by the President of the Institute of Civil Engineers, to state his opinion of the merits of the Whitworth rifle, placed on record his judgment, in the following words, extracted from the printed proceedings:—'As to the relative merits of the Enfield and Whitworth rifles, that is a matter upon which any man who has carefully con-

sidered the subject is competent to come to a conclusion. The small bore would of course in accurate shooting beat the large bore.[1] There is a peculiarity about the Whitworth small bore rifles, which no other similar arms have yet exhibited; *they not only give greater accuracy of firing but triple power of penetration.* For special purposes any description of bullet can be used in them, from lead to steel. The Whitworth rifle, with a bullet composed of one tenth of tin, penetrated through 35 planks, whereas the Enfield rifle (with which a soft bullet is necessary) only penetrated 12. He (General Hay) had found that 'at a range of 800 yards, the velocity added to the hardness of the bullet gave a power of penetration, in the proportion of 17 to 4 in favour of the Whitworth rifle. Velocity might be taken as a certain test, "cæteris paribus," of penetration. The penetration of the Whitworth rifle was enormous, and this in a military weapon was of the highest importance in firing through sandbags, gabions, &c. The Whitworth projectile would penetrate a sandbag and a half: the Enfield only through *one* bag; the Whitworth projectile would go *through* a three feet gabion: the other would only reach the *middle* of it. He thought the merits of the

[1] Mr. Whitworth, in his *Miscellaneous Papers on Mechanical Subjects*, says 'it has often been said that small bores, as a matter of course, will give more accurate shooting than large; but this is only true if the *pieces are such as can be conveniently fired from the shoulder.* There is no reason why the shooting of the larger bore should not be actually better than that of the smaller one (provided the proper projectile and charge of powder be used), as the larger bore will propel a heavier ball, which will have a greater momentum,' p. 9.

"small bore" had never been sufficiently understood. He was quite aware that "small bores" had been made; and it had been stated recently, that the small bore Enfield had beaten the small bore Whitworth; but nothing of the kind had ever taken place. Hitherto the subject, he did not hesitate to say, had been entirely misunderstood, and it was only by such discussions as these, that the public could learn the real facts of the case. It was proper also to state, that the exact bore of the Whitworth rifle had been adopted at Enfield, without acknowledgment, that even the same twist had been given to the rifling — 1 turn in 20 in. — and therefore it would not be very remarkable, if the same accuracy of fire was obtained. *But he had shown, that there were* other things to be considered besides accuracy. Supposing, for instance, that the same accuracy of fire was obtained with the small bore Enfield, as with the Whitworth rifle, there was still the fact of the penetration of the latter being two-thirds more than that of the former. Mr. Whitworth had solved the problem he undertook; namely, how to project, to the best advantage, a given quantity of lead with a given quantity of gunpowder, and *there was no gun in England, at this moment, which would fulfil that condition to the same extent as the Whitworth rifle.*'[1]

As regards the liability to getting foul during practice, General Hay, in reply to a question from the President, Mr. Bidder, said that 'every gun' in which a certain

[1] *Report of the Proceedings of the Institute of Civil Engineers on the Construction of Artillery*, p. 113.

amount of powder was exploded, would become foul. But if the bullet expanded properly, it left the gun, as it were, 'sponged out' after every shot. Should the bullet not expand, the gun of course would not be clean. He ventured to say that the Whitworth small-bore rifle, fired with common sporting powder, would never foul, so as to render loading difficult. If the lubrication were correct, 'there could be no such fouling, even when the rifle was used constantly for a month. He had himself fired 100 rounds one day, 60 rounds the next, then 40 rounds, and so on, and left the gun without cleaning for ten days, when it fired as well as it did on the first day.'[1]

It would be tedious to enumerate the repeated instances in which in every succeeding year the Whitworth rifle has been tried again and again against the Enfield and others, the best productions of the most skilful gun-makers in England, and always with the uniform result of high superiority.

The National Rifle Association have instituted annual matches at rifle shooting, at which the Whitworth has been invariably triumphant over all competitors. At Wimbledon, in 1860, the first meeting was inaugurated by the Queen in person, who fired the first shot from a Whitworth rifle, striking the bull's eye at only *one inch and a half* from the centre, at a distance of 400 yards — a shot which, considering that it

[1] *Ibid.* p. 114. Similar testimony is borne in the *Report of the Ordnance Select Committee on Small-bore Rifles.* Presented to Parliament in March 1863, p. 13.

was in the open air, is probably the most marvellous ever fired from a rifle.[1] On that occasion the Swiss riflemen who had carried off the first prizes in their own country, laid aside their rifles, to use the Whitworth in preference, from its manifest superiority.

Under such circumstances surprise has naturally been excited as to the possible causes in operation, which have so long delayed the adoption by the War Office of an arm expressly designed for the public service. Of this, one explanation centres on the outlay already incurred in arming the forces with the Enfield musket, and the inconvenience apprehended during the period of transition, pending its supercession by any other. As to the cost for altering the machinery at Enfield, so as to adapt it for the production of the Whitworth, it appears that this can be done for a comparatively small sum; and that this once effected, 'the service muskets rifled on the Whitworth principle, could be manufactured at the same cost as the Enfield, the present quality of material and workmanship being the same.'[2]

It, however, admits of little doubt that eventually these obstacles will be overcome, and that ere long the British soldier will be animated by the consciousness of possessing an arm, the most perfect

[1] *Speech of* Mr. Hussey Vivian, House of Commons, June 25, 1861.

[2] *Letter of* Mr. Whitworth *to* Mr. Hussey Vivian, read in the House of Commons, June 25, 1861. Mr. Whitworth is, however, of opinion that it would be wiser to incur at first an additional charge of about five shillings for each musket, in order to cover increased *care* in the making of the barrel, and thus ensure its longer duration.—*Ib.*

that the science of his own country, combined with high mechanical ability, can produce. Already the military advisers of the Minister of War, in a Report of the *Committee on small-bore rifles*, presented to Parliament in 1863, have intimated their conviction that as the tendency of the present system of musketry instruction is calculated to produce ere long a very high standard of shooting throughout the army, the introduction of a weapon of long range and great precision, will naturally increase the general efficiency of infantry, and place it in a position to keep down the fire of the new rifled artillery, which is one of the creations of our own day.

On the other hand, considerations which retard the adoption of a small-bore rifle are set out in the *Report of the Ordnance Select Committee on systems of rifling for small arms*, presented to Parliament in March 1863. These turn chiefly on the wear that takes place in consequence of the percussioning hammers being liable to break, and the nipples to be damaged by the force of the escaping gas. 'The wear in the latter, may, however, be prevented to a certain extent, by bouching the nipple with platinum or copper, and by a very careful fitment of the nipple into its bed; but the Committee are satisfied from the experience they have had, that no amount of precaution is likely to be effectual in preventing the very rapid wearing out of the small-bore rifle in this respect.'[1]

It appears, however, that the pieces tried on this

[1] *Report, &c.*, pars. 61, 62, 63, 64.

occasion as Whitworth rifles, were, in reality, made at Enfield, with the Whitworth bore and rifling; and the evidences of premature wear were ascribable not to the construction of the musket, but to the softness of the material, a defect which would be obviated by the use of homogeneous iron, with platina bouching for the nipples; the extra cost of which would be far more than repaid by the extra duration of the rifle. The Enfield with the Whitworth improvements is said to be unserviceable after 1,500 rounds, but a rifle made by Mr. Whitworth, and used for deer-stalking by Mr. Horatio Ross, showed no signs of decay after firing 7,000 rounds.

Another exception taken by the Commissioners in this Report, has reference to the shape of the cartridge in use for the Whitworth rifle, the increased length of which 'would render it liable to break in the soldier's pouch, and it would be inconvenient to load with.'[1] The objection to the cartridge has since been removed, whilst the other difficulty alleged, relative to the cost of the Whitworth rifle, which the Committee have been given to understand, would exceed that of the Enfield service musket by about *fifteen shillings*, is met by the counter-statement of Mr. Whitworth before alluded to. For these reasons the Committee did not feel warranted in recommending 'the introduction of a rifle of so small a bore as 0·451 inch, for the entire army; but they think that a partial issue of arms having such superior precision, would be attended with advantage; whether to be allotted to special regiments, or distri-

[1] *Report, &c.*, par. 65.

buted among marksmen of known skill and coolness, being a question for higher authorities to decide.'

Finally, in reply to the enquiry whether (assuming that a rifle of smaller bore than that now used should be adopted) any particular pattern arm has shown from experiment any superiority, or whether the gun-trade should be invited to compete for the production of the best weapon? the Committee record their opinion that 'although they have assigned the reasons above for not recommending the general adoption of a rifle of the reduced calibre of 0·451, they think it only just to Mr. Whitworth to acknowledge *the relative superiority of his small-bore rifle even as a military weapon over all the other rifles of similar calibre that have been under trial.* And as the makers of every small-bore rifle having any pretension to special accuracy, *have copied to the letter the three main elements of success adopted by Mr. Whitworth, viz. diameter of bore, degree of spiral, and large proportion of rifling surface,* it is not probable that any further modifications or *quasi* improvements, that might result from the question being now thrown open to the gun-trade, would be attended with any practical advantage.'

The Committee conclude their Report by declaring that 'with the exception of the defect already noticed as to wear, and the difficulty of obtaining ammunition suitable for the rifle as well as the service, the Committee are of opinion that *the Whitworth rifle, taking all other points into consideration, is superior to all other arms as yet produced,* and that this superiority

would be retained if Mr. Whitworth could ensure all the arms being made with equal mechanical perfection.'[1]

With regard to the last condition, it is only necessary to state that, with the machinery used by Mr. Whitworth, the rifle may be reproduced to any imaginable extent, with an accuracy as undeviating as that with which the gold coinage of the kingdom is multiplied by the dies of the Mint.

[1] *Report &c.*, page 68.

PART II.

RIFLED CANNON.

CHAPTER I.

RIFLED CANNON—THE FIRST INVENTORS.

THE revolution in musketry produced by the new development of the rifle, involved of necessity a corresponding revolution in artillery, and especially in field-guns. At former periods, when the powers of the rifle were still limited and uncertain, it afforded little or no check to field-batteries, either in taking up position or in maintaining a destructive fire upon infantry: nor does it admit of question, that during the campaigns of Napoleon the issue of decisive engagements might have been reversed, had gunners at that time, instead of acting securely from a distance of 400 or 500 yards, been exposed to the fire of riflemen whose aim is deadly at more than 1,000.

But as already mentioned[1] the military states of Europe at an early period were slow to supersede the old musket by an improved weapon, and equally tardy at a later one in extending to artillery the same appliances which had so vastly enlarged the power of small arms. It was not till 1830, when the army of Algiers had lost faith in the range of its own weapon as com-

[1] See chap. i. pp. 4, 8.

pared with that of the Arab fire-lock,[1] that attention was earnestly directed to the improvement of the weapon for infantry; but before 1848 upwards of 16,000 rifles were in the hands of the French troops. About the same time the Prussians had 60,000 men armed with their 'needle-gun.' But the moment this impulse was given, it became evident that the imparting of new qualities to small arms must be fatal to the previous ascendency of cannon, and that unless the power of the latter could be augmented in a like proportion, artillery would cease to exert its accustomed influence in deciding the fate of battles.[2] Out of this rational

[1] Le 14 juin 1830, l'armée de l'expédition d'Afrique débarque dans la baie de Sidi-Ferruch. Bientôt les Arabes viennent nous attaquer, et nous les voyons, pointant leurs longs fusils sous des angles très-inclinés, envoyer leurs balles dans nos colonnes à des distances de cinq, six et sept cent mètres. Nos soldats ripostent, comme on leur avait appris à le faire, en tirant à la cible à deux cent mètres au plus, et leurs balles frappent à terre dans le sable. *L'opinion s'établit aussitôt, dans toute l'armée, que les fusils des Arabes portent plus loin que les nôtres!* Et cette opinion, qui peut souvent exercer une influence si fatale sur le moral du soldat, on la laisse subsister pendant des années! On ne cherche pas à lui persuader qu'un fusil, quelle que soit la longueur de son canon, ne peut lancer une balle de 24 à la livre, extrêmement mal faite, plus loin que nos fusils ne lancent une balle, de 19 à la livre, parfaitement sphérique et ayant une grande vitesse.

On ne fait pas remarquer aux soldats que cette grande portée que les Arabes obtiennent n'est pas due aux propriétés de l'arme, et notamment à la longueur de leurs canons, mais à l'inclinaison considérable de l'angle sous lequel ils tirent.—DELVIGNE, *Notice Historique des Armes Rayées*, p. 57.

[2] In 1827 and 1828, a Commission was appointed in France to enquire into the subject of rifled arms, in the course of whose discussion it was urged, that if to the musket they could impart such precision and range as then appeared probable, 'il faudrait réformer la moitié de l'artillerie, parce que la moitié de l'artillerie deviendrait inutile' (DELVIGNE, *Notice Histor. des Armes Rayées*, p. 44). This opinion was

conviction arose the rifled guns of Lancaster and others in England, and in France the *canons rayées*, whose powers of destruction, developed too late to be displayed against the Russians in the Crimea or the Baltic, were manifested with fearful effect at Magenta and Solferino.

The idea of rifling artillery was far from being new; it had been tried in Germany more than a century before our time, and Robins, the accomplished inventor of the 'ballistic pendulum' for determining the relative velocity of projectiles, experimented on rifled field-pieces in England so far back as 1745.[1] M. Ponchara at Paris in 1819, and Montigny at Brussels in 1836, and again at St. Petersburgh in 1836, had in succession renewed the attempt. Colonel Cavalli in Sardinia, and Baron Wahrendorf in Sweden, each carried on experiments in rifling, and combined with it inventions for breech-loading; but the measure of their success was not attested by the practical adoption of any of their plans.

repeated at a later period by Colonel Favé, one of the ablest and most experienced officers in the French army, and a Professor at the École Polytechnique: 'le canon conserve sur la carabine un avantage, ... cependant il ne faut pas se dissimuler que l'efficacité et l'importance des bouches à feu peuvent être notablement diminuées par l'accroissement de portée et de justesse des armes à feu portatives . . . l'artillerie a de grands efforts à faire pour ne pas voir diminuer son influence sur le sort des batailles.'

[1] The twenty-first number of the *Journal of the Royal United Service Institution* contains a paper by Commander R. A. E. Scott, R.N., in which that gentleman has condensed, in an extremely lucid and comprehensive essay, the leading facts relative to the 'progress of ordnance abroad compared with that of ordnance at home.' In this able document will be found a compendious account of the early attempts made to introduce rifled artillery in all the military states of Europe; as well as of the condition of the question at the present day.

Colonel Treuille de Beaulieu made more than one effort between 1840 and 1852 to revive the subject in France, and at length, in 1854, Napoleon III., himself an authority on artillery, convinced by the protraction of the operations before Sebastopol of the insufficiency of smooth-bore siege guns to meet the requirements of modern warfare, directed the resumption of experiments on rifled cannon. Uniting in one piece various suggestions of previous inventors, amongst others of Baron Wahrendorf and Lieutenant Engstroem, some brass guns were grooved under the direction of Colonel Treuille de Beaulieu, and sent for immediate service to Algeria. With further improvements, suggested by their trial there, and afterwards in Cochin China, France was the first to possess herself of rifled field-guns, and the earliest opportunity for the display of their destructive forces was afforded by the Italian campaign in 1856. The guns there employed were rifled with six rounded grooves, and being capable of firing ordinary ammunition as well as elongated projectiles from long distances, they scattered the reserves of the Austrians, rolled back the charges of cavalry, and ploughed through squadrons at close quarters with case-shot and canister.[1]

[1] Commander SCOTT, *Roy. Un. Service Journal*, xxi. p. 10. As it is not intended to extend this notice with a view to comprehend the progress of rifling in other countries, it may be well to state briefly here that *Austria*, having during the Italian war dearly learned the value of rifled artillery, sedulously applied herself to acquire it; and after a comparison of the advantages of lead-coated projectiles, rejected them in order to adopt the French system. She has since been devoting attention to a new species of amalgamated metal for guns, and has lately obtained valuable results from the use of gun-cotton for pieces specially

This result was the signal for a reconstruction of all the artillery of Europe. Impressed with its importance, England was the first of the great powers to follow the lead of France, and so rapid was her advance upon it, that specimens of her newly developed skill in the manufactory of rifled cannon, displayed at the Great Exhibition in London in 1862, called forth the unrestrained admiration of M. Treuille de Beaulieu, who acted as

constructed of bronze. The *Russians* have followed the Austrians' example, and grooved their ordnance on a plan similar to that of the French. *Sweden* has done the same, thus superseding the inventions of her own countryman, Baron WAHRENDORFF, and his collaborateur Lieutenant ENGSTROEM. *Holland*, too, has introduced the French system, believing it to be (as it is described by M. TREUILLE DE BEAULIEU) 'easier procured, more economical, and less complicated' than any other on the continent of Europe. *Spain* used guns rifled on the French system in her war against the Moors, especially at the siege of Tetuan. *Sardinia* at first tried the breech-loaders of CAVALLI, during the siege of Gaeta, but alarmed by the numerous accidents incident to breech-loading, she abandoned it, and having first adopted the French rifling for field-guns, has now extended it to heavy artillery. *Portugal* and *Switzerland* use muzzle-loaders rifled with grooves, whilst *Prussia*, availing herself of the homogeneous iron manufactured by KRUPP at Essen, adheres to breech-loading and lead-coated projectiles. *Belgium* does the same, using BESSEMER'S steel, but adopting a slight modification of the Wahrendorf plan for closing the breech, which 'differs from the Armstrong in this, that while a little extra pressure forces the "vent-piece" of the latter away from the end of the bore, causing a dangerous escape of gas, the valve-face of the Wahrendorf stopper is more fully expanded, and the stopper pushed more tightly against the bolt that supports it in the bore of the gun' (Commander SCOTT, *R. U. S. Journal*, xxi. p. 11, &c.). The *Americans* originally inclined to breech-loading, but have latterly shown a disposition to abandon it, and to trust more to guns of extraordinary weight, preferring the bruising and smashing of ponderous shot to the quick penetration of rifled projectiles. Hence their Dahlgren guns and Columbiads throw shells of more than 300 lbs. each, with a range of 2,000 yards. They, however, rifle their smaller cast-iron guns, and strengthen them with hoops on the 'Parrot' system, resembling that of Captain BLAKELY. *Ibid.* p. 16.

the commissioner of France. Fascinated by the beauty of the English guns, and passing the most cordial eulogium on the surpassing quality and splendour of their workmanship, 'un luxe et une puissance d'outillage merveilleux,'[1] he accompanied his phrase by the consoling reflection that although no examples of French artillery were exhibited in competition with those of Armstrong and Whitworth, still its paramount influence was apparent, in these magnificent productions of its rivals.[2]

The remark, however true, embodied only a part of the truth; for England, though thus suddenly stimulated to exertion, was impelled less by the performance of the 'canons rayées' of France, than by the recently developed powers of the rifle. The cooperation of artillery with infantry in the field rendered each a constituent element in our system of tactics; and the alteration which raised the qualities of the one necessitated a corresponding change in the other.

The invention of gunpowder was prejudicial to the personal skill of the soldier, by transferring to the mysterious powers of the new force that confidence which the archer had previously felt in his own expertness in using the bow. No longer measuring strength in encounters in which each could attest his individual powers; but on the contrary, trained to act against masses where it was next to impossible to observe the effect of individual skill, men had ceased to be

[1] *Rapports du Jury International &c.*, tom. iv. pp. 4, 10.
[2] *Ibid.* p. 10.

marksmen when equipped with no better weapon than the antiquated fire-lock. But now unexpectedly a new order of things had arisen; and the soldier, armed with the improved rifle, was expected, not only to fire, but to hit the mark. To teach him this accomplishment, schools of musketry were established in the army, and under their influence came a revival of the long-dormant skill of the soldier, who soon acquired that confidence in himself which he had previously reposed in his musket.

It became speedily apparent that if a man could be taught to hit ten times, who had previously hit but once in ten, the efficacy of infantry as a body must be held to be augmented in a similar ratio.[1] Military strategy thus became subjected to unavoidable readjustment. As battles have hitherto been fought, it was the practice for opposing forces to array themselves at distances varying from 500 to 1,500 yards. At Waterloo the French and English armies were at first 1,200 yards apart; but as musketry as well as grape-shot was unavailing at such a range, the assailants approached to within 200 or 300 yards of their opponents without

[1] Speaking of the rifle-shooting at Wimbledon in 1860, the *Times* of July 9th said, 'Already we have got the best weapon in the world, and already have we *revolutionised the whole art of shooting*. Foreigners, adepts in the work to which we are but apprenticing ourselves, and who came perhaps scorning such competitors, ended by casting away their own weapons and adopting ours. The Swiss rifleman has learned to look upon our Whitworth as a new power, and to desire its possession as a new sense. The weapons which were taken from these honest Switzers by the French (custom-house officers on their way to England to attend the Wimbledon match) will, if reclaimed, be valued only as ancestral curiosities.'

suffering serious loss. All this required to be altered, the range of the musket being ten-fold enlarged, whilst power and precision had been increased in like proportion. Battalions can now be prostrated who advanced in security before; tumbrils may be exploded half a mile away,[1] and artillery rendered unavailing by the exposure of the men to the fire of small arms, the 'hitting' range of which exceeds that of their own guns. Fieldworks themselves are no longer safe, for rifles that can kill at a thousand yards would have silenced the Russian batteries at the Alma, and sent hardened bullets through the mantlets of Sebastopol.

As this momentous change was not the result of any startling invention, nor the sudden discovery of any new agent or physical power, but on the contrary, was produced by the deliberate application of well-ascertained principles leading to the removal of former defects, the elimination of waste and the concentration of force; it admitted of little doubt that by the judicious extension of this system, the same extensive development which had been manifested in small arms might with equal success be imparted to field-guns and heavy ordnance. Hence the engineers of England, even before Mr. Whitworth had fully completed his improvements in small arms, were actively alive to the necessity of enlarging the powers of artillery.

The ordnance in use, at the period when improve-

[1] General JACOB, in the course of his experiments at Jacobabad, frequently exploded tumbrils, packed as they usually are for service, at a distance of from 1,200 to 1,800 yards.

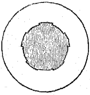
ment began, differed in no essential particular from that employed during the wars of Napoleon; and for rudeness of construction, shortness of range, and uncertainty of aim, it was as primitive and obsolete as 'Brown Bess' herself. One main cause of this stationary condition of artillery during the last two centuries the *Edinburgh Review* in 1859 was disposed to discern in the fact 'of the manufacture of guns being wholly in the hands of military men; no civilian being allowed to interfere, directly or indirectly, with any of the processes; and the enormous stride that has since been so suddenly made simply arose from the fact, that the mechanical appliances of the day have for the first time been brought to bear upon the subject.'[1]

Amongst the earliest, if not the first, who obtained distinction in this pursuit was Mr. Lancaster, who took out letters patent in 1850 for a gun, the chief peculiarity of which consisted in its having an oval, or rather a slightly elliptical bore,[2] with an increasing rapidity in the twist as the spiral approached the muzzle of the gun. Like other hasty measures, the resort to which is attributable to the imperious demands of actual war, the Government incurred considerable expense in the manufacture of this gun; which was tried during the Crimean campaign. Of eight sent to Sebastopol, three burst during the siege; but these were not specially made for the occasion, being old service guns bored on the Lancaster system. Others, however, after-

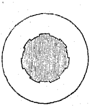
[1] *Edinburgh Review,* August 1859, p. 526.

[2] See a section of the Lancaster system of rifling, Part I. chap. iii. p. 44.

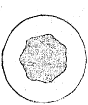
wards underwent the same disaster at Shoeburyness. The cause of this catastrophe was probably to be traced to the unyielding nature of the first projectiles used, which, being made of wrought iron without external fitting, were incapable of accommodating themselves to the 'increasing twist' of the barrel, and, by jamming, they burst the gun in the attempt.[1] This evil it was sought to correct at first by giving the projectile a 'skew' corresponding to the direction of the bore, and eventually by abandoning the accelerating spiral in field-guns; but the result has not been a success, and the Ordnance Select Committee have recently recorded their opinion that the major axis of the ellipse of the projectile, when it begins to rotate, has a liability to overrun the spiral of the gun, and to pinch or act as a wedge with a tendency to burst it. Practically the system of Mr. Lancaster has been eclipsed by those of other competitors; but looking to the characteristic simplicity of the elliptical bore, when



BASHLEY BRITTEN.



LYNALL THOMAS.

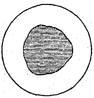


JEFFERY.

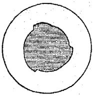
[1] The Lancaster guns at Sebastopol burst near the muzzle: 'on one occasion the whole muzzle was blown off by the increasing strain put upon it; but *having got rid of this weak part*, the gun continued to be used with safety and effect as a howitzer.'—Sir HOWARD DOUGLAS, *Naval Gunnery*, p. 215.

divested of the accelerating twist, it is possible, though not in immediate prospect, that it may yet be turned to practical account.

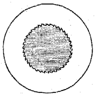
In the course of the next few years the number was considerable of men of mechanical talent who directed their attention with more or less assiduity to the question of rifled ordnance. Of these a large proportion were animated by the desire of applying to projectiles for ordnance the same power of expansion already communicated to balls for the rifled musket. Mr. Bashley Britten and Mr. Lynall Thomas each took out patents in 1855 for projectiles, in which a conical cast-iron bullet had attached to it in rear a hollow belt of lead or other soft metal, which expands during the explosion of the gunpowder, and thus fills the grooves. In Mr. Lynall Thomas's system, the lead coating is fixed mechanically, but in Mr. Bashley Britten's it is securely incorporated with the iron by giving the latter a previous coating of zinc. Mr.



HADDEN.



SCOTT.



ARMSTRONG.

Jeffery about the same time produced a projectile for cannon, much on the plan of the Minié bullet for small arms. Mr. Hadden, from a gun with three circular grooves, fired a non-expanding projectile cast with studs corresponding to the hollows in the bore; and

Commander Scott of the Royal Navy recommended one of an analogous construction, but in which the projections were prolonged till they formed ribs or 'wings,' with long bearings. The modes of rifling were scarcely less numerous, exhibiting various modifications of grooves broad and shallow, angular and deep; and in one, rotation was imparted by fillets or ribs raised upon the bore, which fitted into corresponding grooves in the projectile.

Along with those already alluded to, were several aspirants whose inventions were entitled to equal consideration—Major Vandeleur, Mr. B. Irving, Mr. Lawrence, and others; but independently of the fact that want of space precludes any discussion here of the respective merits of their guns, they have been officially set aside for the present, whilst the attention of the authorities has been bent on the more conspicuous systems of Sir William Armstrong and Mr. Whitworth. The *Committee on Rifled Cannon* appointed by the Secretary of State for War in 1858 to ascertain the best form up to that time offered, reported that from seven guns submitted to them, they placed the two above named in a class by themselves for competitive trials, considering farther experiments unnecessary with any of the others. And somewhat later when Lord Herbert, induced by the fact that some continental states had partially succeeded in applying rifling to old cast-iron cannon, instructed the *Ordnance Select Committee* to make an extensive trial of 32-pounders by six different makers, in order to determine the best system for rifling the stock of smooth-bore guns then

in store, their report was unfavourable to nearly all the competitors. In justice to them it must, however, be stated that, apart from any deficiencies in their several systems, want of success in this instance was mainly ascribable to the inherent unsuitableness of the metal upon which they had to experiment. The result has been that down to the present time, the field has been left almost exclusively to Sir William Armstrong and Mr. Whitworth, the two great rivals who have so nobly contested it.

The Committee above alluded to, whose Report was not made till 1863, represented their inability to recommend any one of the systems of rifling submitted to them as capable of being applied with safety to cast-iron guns, except under such restrictions as to charge as would limit them to use as howitzers. They recorded their distrust of cast iron generally as a material for rifled cannon, either for land or sea service. Of the plans for rifling submitted to them, they awarded the first place to that of Mr. Bashley Britten, on the ground of the comparatively little strain on the gun caused by projectiles like his, fired with small charges of powder. Should the urgency of any crisis hereafter render it necessary to rifle cast-iron guns, they thought that it might be done on his system with less risk than any other, but they trusted that no emergency would ever arise such as would require the use of a material so precarious for the making of rifled artillery.

Throughout the series of events and inventions thus briefly alluded to, it speedily became apparent that the question of *material*, which in the case of the soldier's musket may be said to have been subordinate to that

of mechanical skill, rose into paramount importance when the time had arrived for dealing with artillery, and applying a system of rifling to field-guns and heavy ordnance. In small arms, little difficulty existed consistently with the maintenance of a specified weight, in imparting strength to the barrel sufficient to control the force of such a charge as it was intended to contain; but when it came to the construction of guns of great calibre, designed to hurl to vast distances projectiles of prodigious size, impelled by proportionate quantities of powder, the effect of successive discharges upon the metal were found to be so formidable as to necessitate farther enquiries into the manufacture and manipulation of iron and steel; and thus they carried into the domain of the iron-master problems which had theretofore been treated only by the gun-maker and mechanic. In the art of gun-making the highest point to be attained is the construction of a piece of such strength as to curb the utmost force of whatever explosive compound can be used within it. So long as gunpowder is so ungovernable as to burst guns and mortars, so long must it be regarded as wanting in that perfect obedience which is the first principle of effective service. The *beau idéal* of a perfect gun is one which will give the gunner the positive mastery over gunpowder; in other words, *a gun which cannot be burst.*[1] To realise this requires the combined action of two distinct sciences—those of the metallurgist and the engineer: and the latter, it is clear, can always work up

[1] See a Paper by Mr. LONGRIDGE, *Minutes of Proceedings of the Institution of Civil Engineers*, 1859–60, p. 4.

to the utmost achievements of the former, and furnish artillery whose performance and power is only limited by the endurance of the metal out of which it is made. And although perfection is dependent on other conditions besides the tenacity of the metal, such as the form of the bore, the configuration of the projectile, and the peculiarities of loading, still these latter will render but ineffectual service, unless combined with a material so strong and tenacious as to withstand the utmost violence of explosion.

So long as smooth-bore cannon were alone in demand, the metal chiefly employed was *cast iron,* and to a limited extent bronze, or, as it was called, 'gun-metal,' which, though superior in uniformity of strength, was inferior to cast iron in hardness. But cast and unhammered iron is always more or less porous, and in casting a solid block to be afterwards bored as a gun, the exterior during the process of congelation, being chilled by sudden contact with the mould, is converted into a solid crust before the interior has yet been cooled below melting point. The consequence is, that the mass consists of various strata, each of a different density, and, as stated by Mr. Mallet, in a block of three or four inches diameter it is not unusual, even with the utmost care of the founder, to discover 'a central spongy portion, consisting of scarcely coherent crystals, so loose that dark cavities may be seen by the naked eye, and so soft that a sharp-pointed chisel of steel may be driven into it.'[1] In the course of some experiments

[1] *On the Physical Conditions involved in the Construction of Artillery,* London, 1856, p. 20.

conducted by the American Government to test the quality of cast iron, an 18-pounder gun being submitted to hydraulic pressure, the water sweated through the pores of the metal, forming small mounds of froth upon the outer surface, which eventually collected into drops and trickled off.

These defects in cast iron have of course been more or less corrected by the ingenuity and expertness of those engaged in the manufacture, and the Americans have attained great success in counteracting them by casting cannon hollow and introducing a core, through the centre of which a stream of chill water is kept flowing during the process, so as to ensure a more uniform cooling of the metal, and thus contribute to the homogeneity of the mass. Still no amount of improvement has sufficed to increase the strength of cast metal so as to render it a safe material for rifled artillery. Even where the piece does not burst at an early stage, it becomes shaken by each successive discharge, and manifests its weakness by small fissures around the vent, into which eventually the entrance of the gas tends to rend the piece asunder as if by a wedge.

There are of course exceptional cases in which cast iron has done well. One 32-pounder is known to have fired 3,000 rounds at Sebastopol, and although the vent was enlarged, the bore remained sound and smooth. Hence, some officers of high authority, both military and naval, have protested against any precipitate condemnation of a material which, notwithstanding certain admitted defects, may yet be rendered worthy of confidence. It is likewise a curious fact, stated by

practical men, that cast-iron guns in which the particles of metal have been disturbed by a few heavy charges will apparently rearrange and settle themselves after an interval of rest. And it is said that by allowing two or three months to intervene between the series of discharges, a very much greater number of rounds may ultimately be obtained with perfect safety; and, that cannon cast *some years* before testing stand a greater amount of firing than others cast but a few months previously.[1]

Besides the inconvenience arising from additional weight, any attempt to reinforce the resisting powers of a cast-iron gun by adding to the thickness of the *metal is known to be utterly ineffectual.* Professor Barlow, of Woolwich, many years ago demonstrated that in hydrostatic presses the resistance of iron cylinders to internal pressure is not capable of being augmented by merely augmenting the thickness of their sides, and that beyond a certain point the ratio of strength falls enormously below the ratio of thickness.

Professor Treadwell, of the Harvard University in Massachusetts, working out the physical principles of the same problem as applied to artillery, has shown that it is impossible to increase the strength of cast-iron cannon, in any useful degree, by any increase to their thickness beyond that usually given to them, which, as a general rule, may be assumed to be equal to the calibre.[2] To overcome this difficulty, Treadwell recom-

[1] Commander SCOTT, R.N., *Roy. Unit. Service Journal*, No. xxi. p. 19.

[2] TREADWELL, *On the Construction of Cannon of great Calibre.* Cambridge, Mass., 1856, p. 18.

mended that cast-iron guns should be encased with hoops of wrought iron, in layers placed one above the other, each with an increasing strain, so that the entire mass might oppose a combined resistance to the expansion occasioned by the explosive force of the gunpowder.[1] Like almost every other process recently applied to the improvement of ordnance, the idea of reinforcing guns by outward layers of wrought iron was not new. Colonel Treuille de Beaulieu states that it was proposed to the French Government by M. Goupil in 1833, and tried by Colonel Frederick shortly after in Belgium.[2] The principle has also been applied in this country by Captain Blakely of the Royal Artillery, who, in 1855, took out a patent for a

[1] TREADWELL's process is thus described by himself in a Paper printed by the American Academy, *On the Practicability of Constructing Cannon of great Calibre, capable of enduring long-continued Use under full Charges*, p. 19. 'Now, to obviate the great cause of weakness arising from the conditions before recited, and to obtain as far as may be the strength of wrought iron instead of that of cast iron for cannon, I propose the following mode of construction. I propose to form a body for the gun, containing the calibre and breech as now formed of cast iron, but with walls of only about half the thickness of the diameter of the bore. Upon this body I place rings or hoops of wrought iron in one, two, or more layers. Every hoop is formed with a screw or thread upon its inside to fit to a corresponding screw or thread formed upon the body of the gun first, and afterwards upon each layer that is embraced by another layer. These hoops are made a little, say $\frac{1}{1000}$th part of their diameters, less upon their insides than the parts that they enclose. They are then expanded by heat, and being turned on to their places, suffered to cool, when they shrink and compress, first the body of the gun, and afterwards each successive layer all that it encloses. This compression must be made such, that when the gun is subjected to the greatest force, the body of the gun and the several layers of rings will be distended to the fracturing points at the same time, and thus all take a portion of the strain up to its bearing capacity.'

[2] *Rapports sur l'Exposition Universelle à Londres de* 1862, tom. iv. p. 11.

'method of forming guns with an internal tube of cast iron or steel inclosed in a case of wrought iron or steel, heated and shrunk upon the cylinder.' His specification explained that the substance of the patent consisted in rendering the internal diameters of the outer collars so much smaller than the external diameters of the inner ones, that, after being cooled, the former maintain a uniform tension or permanent strain upon the latter. Captain Blakely's plan presents a remarkable analogy to the process of Treadwell, described in a previous page; but the patentee has stated before the Ordnance Committee of the House of Commons, that between the two there is neither relation nor resemblance.[1]

The Ordnance Select Committee in 1861 reported to Lord Herbert, then Secretary of State for War, that Captain Blakely's method, and no other, is the principle

[1] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1863, 4631, 4644. Mr. MALLET, of Dublin, and Mr. LONGRIDGE, were about the same time occupied by the same enquiry; the latter substituting wire instead of the hoops recommended by Treadwell, or the coil adopted by Captain BLAKELY. 'It was upon this principle that Mr. MALLET about 1855 built up the monster mortar of upwards of 50 tons weight with a diameter of three feet and throwing a shell of 26½ cwt. But the experiments made with it at Woolwich showed a tendency to separation between the trunnions and the cascable; the expansive force of the powder causing the latter to yield; and openings having shown themselves between the hoops, it became necessary to discontinue firing from apprehensions of danger.'—Sir HOWARD DOUGLAS's *Naval Gunnery*, p. 174. The Earl of ROSSE, speaking of this monster engine of war, in a recent conversation with Mr. NASSAU SENIOR, said such a shell would be in fact 'a flying mine'—its explosion would destroy every building in the vicinity of its fall, as its weight would render it impossible to remove it from the spot where it might light, and the tube of its fuse would emit off volumes of fire defying all attempts to extinguish it.

employed in the manufacture of the Armstrong guns, and it appears to them that whatever dispute there may be as to originality or priority of invention, and the use of terms between Captain Blakely and Sir W. Armstrong, there is little or none in the matter of fact. 'Both make, or propose to make, strong guns in the same way; nor is the principle in any way new.'[1]

Captain Blakely's system has not as yet been favourably regarded by the British Government, and although after evidence of its performance in 1855, two experimental guns were ordered by the War Office, some considerable time was allowed to elapse before they were tried at Shoeburyness. The Ordnance Select Committee at length expressed their opinion in 1859, that 'taking into consideration the different expansive powers of wrought and cast iron, guns so constructed could never be considered safe, as they might at any time burst.' This they repeated in 1863, under the conviction that no external hooping can avert the consequences of the internal action of the gases on the softer metal, although it may render it less destructive. The external envelope, they say, no doubt assists cast iron to resist a strain when there are no fissures and no 'rending' action; but this is not the ordinary cause of guns bursting, those destroyed being almost invariably condemned for the state of the metal round the vent. The first gun, however, which Captain Blakely produced in 1854, underwent a competitive trial with a cast-iron gun and a brass one, both in use in the

[1] See Appendix to the *Report of the House of Commons' Committee on Ordnance in* 1863, p. 551.

service, in the course of which the cast-iron one gave way after 351 rounds, and the brass one after 479, whilst the Blakely stood 3,389 shots. Upwards of 400 guns on his plan have since been made in England, and 'thousands,' as the patentee states, in other countries, chiefly in France and the United States, where they were used in repelling the Federal attack upon Charlestown in the spring of 1863.[1] Captain Blakely, like many other inventors, complains of the reluctance which he found on the part of the Ordnance Select Committee at the War Office to subject his guns to a thorough trial, notwithstanding his offer to bear all the cost from his private resources.[2]

Cast iron, whether singly or in combination with welded-coil hoops, being thus more or less discredited for the manufacture of heavy ordnance, attention was necessarily turned to *forged* or *wrought iron* as a safer, although a costlier substitute. But here, again, disappointment ensued. Various methods of forging and welding were tried, but, in practice, all failed to reduce the mass to a uniform density. In defiance of every precaution flaws occurred, which escaped detection under the keenest scrutiny; and these, when exposed to the searching force of gunpowder during explosion, ensured the ultimate destruction of the piece.

The prodigious powers of the Nasmyth hammer, the blows of which descended with a weight of many tons, could not conquer the difficulty; and the failure was felt

[1] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1863, 4750, 4752.

[2] See *post*, Part III. Conclusion, p. 314.

as a national disappointment. In one signal instance the attempt to produce in this country a cannon of wrought iron on a grand scale was attended with ultimate success; but even here the security of the piece was attributable to its gigantic dimensions, and not to the absence of flaws. The instance alluded to is that of the great Horsfall gun. That formidable piece of artillery was made by the Mersey Company at Liverpool, and is one of the finest specimens of forging on a grand scale that this country has ever produced. It weighs upwards of 24 tons, and has a smooth bore 13 inches in diameter, sufficient to discharge a spherical ball of more than 300 lbs. weight. The idea of making this monster cannon originated, like many others, during the anxieties of the Crimean campaign, but the gun itself was not finished till some time after the war had closed. Conformably to the intention of the company by whom it was manufactured, it was generously presented by them to the nation, on the sole condition that it should be used against an enemy. Some years were spent in bootless correspondence with the War Office and the Admiralty relative to compliance with forms then rigorously enforced, but since altered, with reference to trials and charges; but at last in 1862, the gun which had already crushed and broken up iron of $4\frac{1}{2}$ inches thick was moved to Shoeburyness, to have its prodigious powers of crushing iron plate farther tested against the Warrior target.[1]

On the 16th September 1862, it was laid at a range

[1] See the memorable proceedings of this day, described Part III. chap. iv. p. 288.

of 200 yards, and with a charge of 75 lbs. of powder, it sent a solid cast-iron projectile weighing 280 lbs., with a velocity of upwards of 1,100 feet in a second, through the central plate of a target formed of 18 inches of teak covered by $4\frac{1}{2}$ inches of iron, and lined with 1 inch of the same. The shot tore open a hole more than two feet in diameter, and caused rents and fractures in numerous directions. By the force of the concussion bolts were started, and portions of the broken shot mingled with fragments of iron-plate were driven deep into the bulkhead behind.

Ten days after, the experiment was repeated with a similar charge, but at a range of 800 yards. Here, whilst the velocity was duly maintained, the accuracy of the gun proved inferior to its power, and out of four rounds, two failed to strike. One rebounded from the earth with such force as to lodge in the target, breaking through the iron-armour at the juncture of two plates, in each of which it caused an extensive fracture, burying itself in the timber behind, bulging out the skin and rending the ribs, but it failed to penetrate fairly 'within the ship.' The last shot struck the upper corner of the target and broke away a fragment two feet in length by eighteen inches deep.[1]

It is remarkable that the Horsfall gun had amongst other original flaws of more or less magnitude, one *thirteen* inches long, and although these remained but little affected, it remains to be seen how far the gun could

[1] The injuries caused by these shots are shown upon the *Frontispiece.*

endure more prolonged firing. The experiment thus demonstrated the capability of smooth-bore wrought-iron guns of great size, when properly forged, to endure very large charges of powder when firing spherical shot; but beyond this, no new fact was elicited, the power of any large gun sufficiently strong to inflict destructive injuries at short ranges having been previously known.

Solid iron in any form, produced in this country at that time, whether of casting or forging, being thus found unsafe for the manufacture of heavy artillery,[1] there appeared to be only one alternative, namely, to *build up* heavy guns by arranging hoops of homogeneous metal and welded-coil iron around an inner tube of steel; so that the interior of the barrel, whilst it bears the first shock of the explosion, is fortified against the effects of the strain by the tension and support of the outer concentric layers. Hopes were confidently entertained that British enterprise would sooner or later raise the manufacture of cast steel to the same degree of excellence which it had already attained in Prussia. And the efforts to provide a substitute made in the meantime by the two great inventors who have given their names to the Armstrong and Whitworth systems respectively, will come under notice in the following chapters.[2]

[1] See Sir WILLIAM ARMSTRONG'S *Paper on the Construction of Wrought-Iron Rifled Field-Guns. Appendix to the Report of the Select Committee of the House of Commons on Ordnance*, 1862, p. 158.

[2] See the process of forming welded coil, as adopted by Sir WILLIAM ARMSTRONG, Part II. chap. ii. p. 106; and the method of forging the homogeneous iron, used for the guns of Mr. WHITWORTH, Part II. chap. v. p. 177.

CHAPTER II.

THE ARMSTRONG GUN.

WHILST Mr. Whitworth was occupied in 1854 in investigating the elements of the system which he applied with so much success to the rifle; a competitor, who has since attained high distinction in the same field, was sedulously engaged in searching for the means of extending an equivalent improvement to artillery. Sir William George Armstrong, a descendant of one of the old Border families, was educated for the profession of the law. His own tastes inclined him to be an engineer rather than a jurist, but unlike many another similarly circumstanced, who

> Penned a stanza when he should engross,

he devoted himself resolutely to his adopted pursuit; and till he was thirty-seven years of age, he practised with success as member of one of the most eminent legal firms in Newcastle. Still, the portion of his life which he passed in his office forms but an episode in his career: the passion for mechanical science which he manifested even in his boyhood,[1] he continued to cherish

[1] A biographical notice of Sir William G. Armstrong, C.B., which appeared in the *London Review*, May 3, 1862, says: 'From his cradle nature formed him for an engineer. All his childish amusements had

concurrently with his legal pursuits, and eventually he withdrew from the one to devote himself exclusively to the study of the other.

His earliest distinction as an engineer he achieved while still practising as a solicitor. It is connected with an incident, the influence of which is highly indicative at once of the bent and the capacity of his mind. During an excursion in a mountainous district of Yorkshire about the year 1835, his attention was attracted to the waste of power in a stream which, after descending from a considerable height in successive cascades and rapids, exhausted the last remnant of its power in turning a mill-wheel at the foot of the hill.

Although the force required was dependent on the altitude or 'head' from which the water came, he observed that the portion in use was taken from a level which formed less than a twentieth part of the whole descent. Struck with the inadequacy of a single wheel as a means of realising the full power of such a fall, and perceiving the practicability of rendering the entire head available by conducting the water in an iron pipe, and causing it to act upon suitable machinery below, he applied himself to devising an engine to be worked by water-pressure.[1] Such was the origin of the hydraulic

relation to mechanics. He used to employ himself when only *five* or *six* years old in setting a number of spinning wheels in motion by means of weights descending on strings from top to bottom of his father's house, and in making these wheels perform imitations of pumping water, grinding corn,' &c. &c., p. 418.

[1] See a *Paper on Water-Pressure Machinery*, by Mr. William G. Armstrong of Newcastle, in the *Proceedings of the Institution of Mechanical Engineers*, Birmingham, 1858, p. 127.

crane, and other forms of machinery of the same class, of which he became the author; and although the idea had previously occurred to others, and attempts had been made to render water subservient to like objects in Hungary, as well as in the mines of Saxony and Cornwall, former appliances for this purpose were not only unknown to Sir William Armstrong, but they were so entirely different from his own, that his merit as an inventor remains incontestable.[1] From the first idea of taking advantage of mountain streams, he proceeded to avail himself of the force residing in town supplies of water drawn from considerable elevations, and this led eventually to the construction of towers into which water was raised by the steam-engine in order to give the required 'head.' In addition to cranes for loading and unloading ships in the great docks at Liverpool, London, and elsewhere, the newly organised power has been applied amongst many other purposes to the opening and closing of dock-gates, swing-bridges, and sluices, which it effects with a rapidity limited only by considerations of safety or convenience. 'At the foot of every crane,' says a writer in a recent number of the *Quarterly Review*, 'under the piston of every hoist, at every dock gate, unseen and noiseless, the power lies dormant: but a woman's hand, applied to a small handle, will set in motion a force sufficient to raise a mass weighing fifty

[1] *Minutes of Proceedings of the Institution of Civil Engineers*, Sept. 1842, p. 143. *Ibid.* May 7, 1850. A *Paper* by WILLIAM GEORGE ARMSTRONG, Esq., *On the Application of Water-Pressure as a Motive Power for working Cranes and other descriptions of Machinery.*

or one hundred tons, and either to place it in the hold of a ship, or deposit it in any spot within reach of the arms of the crane. With equal ease the gates of locks 100 ft. in width are opened or shut, and the smallest as well as the heaviest works of the dockyard done without a stranger being able to perceive what it is that sets everything in motion.'[1]

The success of this invention was the turning-point in Sir William Armstrong's career. 'Up to this period,' says a local journal,[2] in a biographical sketch of its distinguished townsman, 'he had been following the profession of a solicitor, but his strong bias for mechanical and scientific pursuits, and the successful results of his hydraulic crane, led him to relinquish that profession, and, in conjunction with a few friends, who cooperated with him, to commence the Elswick Engine Works, which have since grown into one of the largest and most important establishments in the kingdom.'

'In the autumn of 1840 another subject caught his attention. A jet of steam was by chance escaping from a fissure in some cement of chalk and oil placed round the safety-valve of a steam-boiler on a railway near Newcastle. It was found to be charged with electricity. Sir William was happily one of the first observers of this then unknown phenomenon. A long series of experiments was the result; and at last he succeeded in making his well-known *hydro-electric machine*, the most powerful means ever devised for

[1] *Quarterly Review*, Nov. 1863.

[2] The *Gateshead Observer*, March 12, 1859.

producing frictional electricity. For these successful labours he was elected, at an unusually early age, a Fellow of the Royal Society.'[1]

Such were the pursuits in which he was engaged, when England was disquieted by those rumours of disasters in the Crimea, which sufficed for a time to

fright the isle from her propriety.

The fate of the battle of Inkerman in November 1854 was decided by two 18-pounder guns, which by almost superhuman efforts were got up late into the field, and these, by their superior range, were effectual in silencing the Russian fire.[2] Sir William Armstrong was amongst those who perceived that another such emergency could only be met by imparting to field-guns the accuracy and range of the rifle; and that the impediment of weight must be removed by substituting forged instead of cast-iron guns.[3] With his earliest design for the realisation of this conception, he waited on the Secretary for War in December 1854, to propose the enlargement of the rifle musket to the standard of a field gun, and to substitute elongated projectiles of lead instead of balls of cast iron. Encouraged by the Duke of Newcastle, he put together his first wrought-iron gun in the spring of 1855. But a considerable time elapsed

[1] *London Review*, May 3, 1862, p. 418.

[2] Russell's *British Expedition to the Crimea*, p. 205.

[3] In the course of his examination before the House of Commons' Committee on Ordnance in 1863; Sir William Armstrong has embodied a brief history of the whole of the transactions connected with his system of rifled ordnance; which will be read with deep interest. It occurs at p. 133 et seq. of the published *Report* and *Evidence*.

before he considered it in a condition to be brought officially under the notice of the Government. The gun did not spring Minerva-like and perfect from his brain. It was the product of deep reflection, indomitable perseverance, and thoughtfully elaborated experiments, extending over a period of nearly three years, during which he had to struggle with all the usual initial difficulties. At a banquet given in his honour at Newcastle in 1859, he stated that in summer his first trials were conducted about dawn, upon the seashore of Northumberland, where the range was free from intrusion; and that during other seasons of the year he occupied a solitary hut amongst the moors at an elevation of 2,000 feet; his target being placed upon the side of a valley, across which he fired his projectiles by night as well as by day, being enabled to maintain his fire upon an object after darkness had set in, by means of the *nyctoscope,* an ingenious instrument of his own invention.[1]

Of six guns which he was authorised by the Minister for War to construct, the first, a 3-pounder, was reported on in November 1855 by the War Office Select Committee, who recommended further experiments on a larger scale. It was re-bored up to a 5-pounder, and

[1] The principle of the instrument, as described by himself, was to render the image of an object in the rear, or at one side, visible upon a vertical line in a mirror, when the gun was laid upon the true object. A lamp attached at night to the false object became visible upon the same mark in the mirror, when the gun was in line with the object aimed at. The vertical adjustment for elevation was effected by a spirit-level clinometer, forming part of the instrument.

fired at Shoeburyness with marked success both in accuracy and range. A second, an 18-pounder, was submitted for trial in 1858, and the results were so unexpected that Colonel Mitchell of the Royal Artillery, in a special report, notwithstanding his scruples as to breech-loading, stated that this gun 'appeared to afford a reasonable expectation that artillery might not only regain that influence in the field, of which to a certain extent the recent improvement in small arms had deprived it, but that that influence might be materially increased.'[1] Lord Panmure, then at the head of the War Department, regarded the new piece as 'a most valuable contribution to our army, and the experiments being conclusive as to the flight and accuracy of the projectiles,' he gave orders that three more guns should be prepared, a 12-pounder and two 18-pounders, together with the necessary projectiles, 'to be handed over to the artillery to knock about, and be reported upon as to their endurance of work, in comparison with our service guns.'[2] With these, and with a 32-pounder and others of the same construction, trials were made, which towards the close of 1858 led to the adoption of the Armstrong gun for special service in the field, under circumstances which will be presently adverted to. Meanwhile it is necessary to give some account of a gun which has excited such high hopes, and which occupies so distinguished a position in the annals of artillery.

[1] *Report of the Select Committee of the House of Commons on Ordnance*, 1862, App. p. 165.

[2] *Ibid.* p. 166.

The earliest aim of its inventor was the production of a field-piece, constructed for loading at the breech, with mechanical appliances to facilitate the pointing of the gun and counteract the recoil. His first conception was to have elongated projectiles of lead, or lead hardened by an admixture of antimony or tin; but discovering their liability to distortion, he finally adopted a projectile of iron coated with lead, to which rotation is imparted by its being forcibly driven during the explosion into the numerous grooves with which the bore is rifled.

But as the substitution of a cylindrical bolt for a spherical ball, and the force required to project it through a barrel slightly contracted towards the muzzle, involved the necessity of strengthening the gun to enable it to resist the increased strain and impart the required velocity—the attention of Sir William Armstrong was early directed to the selection of a metal possessed of greater tenacity than that of cast or ordinary wrought iron. Steel has nearly double the tensile strength of the latter, and more than seven times that of cast iron; but in the state of the manufacture as it then existed, it was considered to be unreliable in a mass of sufficient size for large guns. Besides, both in it and in shear-steel, Sir William Armstrong was of opinion that the tenacity was always less in a lateral than in the longitudinal direction; whereas lateral strength was the high essential of a cannon. Reverting therefore to the practice adopted in making musket barrels of twisting bars of iron into spiral tubes and forging them, Sir

William resorted to a similar process, but on a greatly enlarged scale. In malleable iron when drawn into bars, the particles assume a fibrous form, somewhat resembling a bundle of threads strongly adhering to each other and possessing their chief tenacity in the direction of their length. Availing himself of this well-known property, he proceeded to coil iron bars of sufficient thickness into cylinders, which he afterwards welded into solid hoops, by which 'means the longitudinal strain of the slips becomes opposed to the explosive force of the powder; and the weldings being transverse with the bore, have no important influence in lessening the strength of the barrel.' [1]

Steel being a harder substance than iron, and therefore more adapted to form the surface of the bore and receive the rifling, he at first applied it in the form of a tube for the inner lining; obtaining the necessary strength by encircling it with welded hoops shrunk on with initial tension on the principle laid down by Treadwell,[2] and adopted with more or less variation by

[1] *Report of the Select Committee of the House of Commons on Ordnance*, 1862, p. 158. Sir W. G. ARMSTRONG'S *Address to the Institution of Mechanical Engineers at Sheffield*, August 1861.

[2] See *ante*, Part ii. ch. i. p. 89. Like almost every other element in the construction of fire-arms, the adoption of 'welded coil' for artillery has given rise to a contest as to priority of invention, in the course of which Capt. BLAKELY not only claims precedence for himself, but alleges that Mr. LONGRIDGE and Mr. MALLET had both used it before Sir WILLIAM ARMSTRONG applied it to his rifled cannon. (See Capt. BLAKELY'S *Evidence before the Select Committee of the House of Commons on Ordnance*, 1863, 4,627, &c., 4,624, 4,638, &c.) Its application by the French to making the tires of wheels for locomotive engines appears to have taken place some years before its adoption for cannon in this country.

others. He afterwards made the inner tube, as well as the external hoops, of coiled iron; but mature experience has demonstrated the superiority of steel.[1]

The process of welding the coils for a 25-pounder gun is thus described by a writer in the *Times*: 'In one corner of the Royal factory is a long narrow furnace, in which are placed bars of the finest wrought iron, two inches square and forty feet long. In the manufacture of a 100-pounder Armstrong gun, these would be required of no less than 90 feet in length. In front is a roller, round which a bar, directly it is of a white heat, is wound slowly out of an aperture in the door of the furnace. When the whole has been coiled as close as

The Ordnance Select Committee of the War Office, as has already been stated (p. 91) declare the two methods to be identical. The Butterley Company in Derbyshire, who manufacture for Captain Blakely, on being admitted to inspect the process at Woolwich, said in his presence that the plan was precisely that on which they had been making guns under his direction since 1855. (*Ib.* 4,627, 4,638, 4,676.) Proceedings were attempted by him to contest the validity of Sir W. Armstrong's patent, when he was advised to desist, on the grounds that the alleged infringement being the act of servants of the crown, an action could not be sustained by a subject. (*Ib.* 4,665, 4,670). As to the question of originality or priority Sir William has met it frankly by the following declaration:—'my gun is peculiar in being mainly composed of tubes, or pipes, or cylinders, formed by coiling spirally long bars of iron into tubes, and welding them upon the edges, as is done in gun barrels. *Now, whether any one had conceived that idea before, is beyond my power to say, but I feel assured that no gun up to that time had been actually made upon that principle.* The whole difficulty lay in the making. It is very easy now with all our knowledge and experience, to define how such coils are to be made; but at that period, it was a very difficult matter to accomplish, and it was not until I had made very many unsuccessful attempts, that I succeeded in satisfactorily carrying it out.' *Evidence* &c. 3,163, p. 133.

[1] *Report of the Committee of the House of Commons on Ordnance* 1862, Evidence 1843, 1849, 3,163, 3,507, &c.

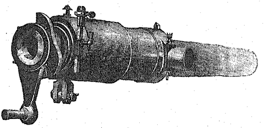
possible, the roller is turned on end; and the coil, having then much the appearance of a flattened cork-screw three feet long, is wheeled away to another furnace, where it is heated to a bright white, placed in a case of iron under a steam hammer, and welded by tremendous blows till it becomes about *two* feet *six* inches long. Three of such tubes are sufficient for a 25-pounder gun,' [1] and are united by welding the joints.

On the first appearance of the Armstrong gun nothing more materially conduced to its extraordinary popularity than the circumstance of its loading at the breech instead of the muzzle. Not that there was any novelty in the idea; for the Chinese from time immemorial have had guns so constructed, and almost every European nation has at one time or other occupied itself with the attempt. In England within the last century upwards of 120 patents have been taken out for breech-loading small arms, and 40 for artillery. Even as regards the form of its introduction, Scoffern says the system of Sir William Armstrong very closely resembles a breech-loading cannon now in the Tower, taken from the wreck of the war ship the 'Mary Rose,' which foundered in the reign of Henry VIII.; and Smiles, in his *Industrial Biography,* says the museum of the arsenal at Venice contains a specimen dredged up from the Adriatic which embodies the same idea in a very rude form.[2]

[1] *Times*, January 24, 1860.

[2] See SCOFFERN'S *Projectile Weapons of War*, p. 340. Sir HOWARD DOUGLAS, *Naval Gunnery*, p. 196.

In Sir William Armstrong's case, however, breech-loading instead of a matter of choice became a matter of necessity as soon as he had decided on rifling a lead-coated projectile by forcing it by a pressure equal to several tons[1] into the grooves of the barrel, since in order to ensure its filling the bore it was indispensable to make the projectile of a greater diameter than would



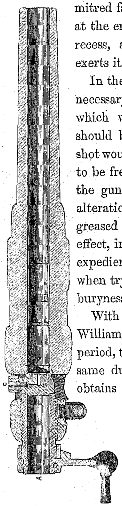
THE ARMSTRONG GUN.

enter the muzzle. The plan which he adopted was the attachment at the rear of the gun of a powerful screw, which, having a hole through the centre so as to render it a prolongation of the bore, admits the introduction of the projectile with a cartridge and greased wad;[2] and these being deposited within, a vent-piece[3] with a

[1] Commander SCOTT, R.N., in a *Paper on Naval Ordnance* in the *Roy. Unit. Serv. Journal*, vol. v. p. 427, says that the plan of rifling the projectiles for cannon by compression was first adopted and perfected by the Prussians.

[2] Sir W. ARMSTRONG'S *Speech at the Institut. of Civil Engineers*, Feb. 1860.

[3] So multifarious are the claims of rival inventors, that the right of Sir WILLIAM ARMSTRONG to the invention of the 'vent-piece' has been called in question; and it is said that there is a French gun in the Museum at Woolwich with a vent-piece, which is said to be identical



SECTION OF THE ARMSTRONG GUN.

mitred face, fitting a corresponding mitre at the end of the bore, is dropped into a recess, against which the great screw exerts its pressure, and closes the breech.[1]

In the earlier Armstrong guns it was necessary that the portion of the bore which was occupied by the projectile should be perfectly clean, otherwise the shot would not enter freely, and water had to be freely used in consequence; but in the guns now issued for service, a slight alteration in the bore has enabled the greased wad to be applied with perfect effect, in substitution for sponging — an expedient first adopted by Mr. Whitworth, when trying his rifled brass guns at Shoeburyness in 1859.

With respect to the vent-piece, Sir William Armstrong intimated at an early period, that it is not expected to have the same durability as the gun; besides it obtains its name from its being made to

with that in the Armstrong gun. The *Edinburgh Review* for April 1859 says, 'The Armstrong "vent-piece" is understood to have been used by the Prussians, and by others in this country, before being adapted to his gun,' p. 530.

[1] In the accompanying sketch and diagram, the breech-screw is shown at A, and at B the vent-piece and touch-hole C.

contain the touch-hole, which being the most perishable part of all ordnance, it is better, rather than insert it in the body of the gun itself, to place it where it can easily be renewed. Two vent-pieces are attached to each gun, so that if one of them be disabled, the other is ready to replace it.

The breech-loading apparatus is undoubtedly the most assailable portion of the Armstrong system, and profoundly scientific engineers professed to discern in its conception the genius of the accomplished amateur rather than the sagacity of the practically educated mechanic. They contended that the 'slot' for the admission of the vent-piece renders that region, which ought to be the strongest, the weakest portion of the gun, and they urged that by making the breech-screw hollow, the vent-piece which has to resist the full fury of the explosion, instead of being fortified behind at every point by a buttress of solid metal, has no other support than the rim of the iron cylinder, containing the hollow breech-screw; which therefore acts merely as an annular prop round the circumference, but is insufficient to prevent distortion at the centre, where the vent-piece is inadequately supported by it.

Still, even in the heyday of popularity, there were those who hesitated to accept the theory of breech-loading cannon under any form or construction. Its complexity was thought to overcome its advantages:[1] the fact was persistently pointed to, that although other countries had for centuries been in search of the

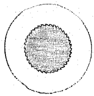
[1] *Edinburgh Review*, April 1869, p. 530.

same object, no military power in Europe had yet produced a successful breech-loading gun. On the other hand, it was contended that incipient disappointment was not hastily to be confounded with ultimate failure, in an experiment by no means exhausted, and the successful issue of which held out the prospect of so many advantages. The risk of accidents from improper loading would be reduced by it, and injury or decay in the piece might be arrested from the increased facilities for detection. Ease and rapidity of firing would be vastly enhanced, especially at sea, where the difficulty is augmented by the motion of the ship; besides which, both there and behind batteries the necessity for exposure of the men is avoided, and the security increased of those serving the guns. 'I am not aware,' says Mr. Westley Richards, himself a high authority, 'of a single qualification belonging to a muzzle-loading gun that may not be possessed in an equal degree by a good breech-loader, in addition to those peculiar to itself, if they can be realised.'[1] This consummation, however, Mr. Westley Richards regrets has not yet been attained even by Sir William Armstrong, in whose gun, he says, there are 'defects admitted in the construction of the breech, whence accidents have not unfrequently occurred by the escape of gas and the breaking or blowing away of vent-pieces. This failure, however, is not to be attributed to breech-

[1] WESTLEY RICHARDS *On Breech-Loading for Military Weapons*, p. 14. Sir WILLIAM ARMSTRONG has given in detail his own views of the advantages of breech-loading; in his evidence before the Committee of the House of Commons on Ordnance, 1863, p. 138.

loading as a system, but to the construction of a particular gun.'[1] In like manner Captain Blakely, himself an advocate of breech-loading, and regarding it as 'very desirable *if we could get it*,' is not acquainted with any system yet divulged on which he could place great reliance; and he objects to the Armstrong breech-loader because the vent-piece 'is only a valve, and the first principle of every valve being that the internal pressure should *render the valve tighter*, Sir William's is a diametrically opposite system,' the tendency of the internal force being to open instead of to close it.[2]

The *rifling* of the Armstrong service gun consists of spiral grooves forming what is termed a 'fluted bore.' The number of grooves he has varied from eight in the first 3-pounder to thirty-eight in the 9-pounder field-gun, and seventy-six in the seven-inch bore, called a 100-pounder.[3]



RIFLING OF THE ARMSTRONG NINE-POUNDER.

'It is an error,' says the Belgian General Borman, in his work on *The Shrapnel Shell*, 'to suppose that the value of a system of ordnance depends on the gun alone; whether with a smooth or a rifled bore, the *projectile* has always a more extended influence than the piece which throws

[1] WESTLEY RICHARDS *On Breech-Loading for Military Weapons*, p. 14.

[2] *Report of the Committee of the House of Commons on Ordnance*, 1863. *Evidence* 4,682.

[3] The rifling of the Wahrendorf gun resembles that adopted by Sir W. ARMSTRONG.

it.' This truth was consistently kept in view by Sir William Armstrong, and the configuration of his projectiles, whether solid or hollow, has been uniformly calculated to take advantage of the principle that an elongated shot admits of increase to the weight, without augmenting the resistance of the air by increasing the sectional area. The forms of projectiles which he tried were exceedingly numerous, and he came to the conclusion that the one best adapted for accuracy is that which is the nearest practicable approach to a plain cylinder, with flat or nearly rounded ends.[1]

But his aim was mainly directed to construct such a hollow projectile as would unite in itself the several

[1] *Report of the Select Committee of the House of Commons on Ordnance*, 1862. Appendix, p. 160. In the course of his experiments on the rotation of his projectiles occasioned by the rifling, Sir WILLIAM ARMSTRONG has recorded the following curious observation: 'The peculiar influence of rotation in giving persistency of direction to the axis of a projectile is entirely distinct from that which it also possesses of correcting the tendency to aberration arising from irregular form or density; and in order to investigate experimentally the nature of this action, I constructed an apparatus by which a cylindrical bullet could be put into extremely rapid rotation, and be then suspended in a manner which left it free to turn in any direction. When thus suspended, the rotating bullet exhibited the same remarkable properties as are possessed by the revolving disc in the recently-invented instrument called the *Gyroscope*. When pressure was applied to either end of the axis, the movement which took place was not in the direction of the pressure, but at right angles to it. Thus a vertical pressure deflected the axis horizontally, while lateral pressure deflected it vertically. But the important point elicited was this, that the time required to produce these indirect movements became greater as the velocity was increased, and, consequently, that the amount of deflection produced in a given time by a given pressure, diminished as the rotation was accelerated. Now, all disturbing forces which operate upon a projectile during its flight must necessarily be of very short continuance, and can therefore have but little influence in diverting the axis when thus stiffened by rapid rotation.'

characteristics of solid shot — shrapnel and canister; and this he accomplished by the production of his 'segment shell,' which can best be described in the language of its inventor:— 'It consists of a very thin cast-iron shell, the interior of which is composed of *forty-two* segment-shaped pieces of cast iron, built up in layers around a cylindrical cavity in the centre, which contain the bursting charge and the concussion arrangement. The exterior of the shell is thinly coated with lead, applied by placing the shell in a mould, and pouring melted lead around it. The lead is also allowed to percolate among the segments, so as to fill up the interstices, the central cavity being kept open by the insertion of a steel core. In this state the projectile is so compact that it may be fired through six feet of hard timber, without injury; while its resistance to a bursting force is so small, that less than one ounce of powder is sufficient to break it in pieces. When this projectile is to be used as a shot, it requires no preparation, but the expediency of using it in any case otherwise than as a shell, is much to be doubted. To make it available as a shell, the bursting-tube, the concussion arrangement, and the time-fuse, are all to be inserted; the bursting-tube entering first and the time-fuse being screwed in at the apex. If then the time-fuse be correctly adjusted, the shell will explode when it reaches within a few yards of the object; or failing that, it will burst by the concussion arrangement when it either strikes the object, or grazes the ground near it. Again, if it is to act as

"canister" upon an enemy close to the gun, the regulator of the time-fuse must be turned to zero on the scale, and the shell will then burst at the instant of quitting the gun. In every case the shell, on bursting, spreads into a cloud of pieces, each having a forward velocity equal to that of the shell at the instant of fracture.'

'One of these shells having been burst in a closed chamber where the pieces could be collected, they consisted of 106 pieces of cast iron; 99 pieces of lead; and 12 pieces of fuse, &c., making in all 217 pieces. It was no uncommon thing for one of them to make 100 holes in a column of targets, at a distance of 3,000 yards, and as a large proportion of the pieces was derived from the lead, it would be seen that the lead added greatly to the efficiency of the shell.'[1] The merits of this remarkable missile are incontestable, and the House of Commons of 1863 have stated in their report that the testimony was unanimous in describing it 'as the most destructive weapon ever used against

[1] Sir WILLIAM ARMSTRONG'S *Speech at the Institution of Civil Engineers*, February 1860. Like so many other points connected with the recently improved construction of ordnance, the originality of the time-fuse invented by Sir WILLIAM ARMSTRONG for his 'segment shell' has been contested by General BORMANN of the Belgian service, who asserts that he was the first inventor, although he admits that Sir WILLIAM introduced modifications in order to adapt it to his own shell. In the justice of this claim the Ordnance Select Committee, to whom General BORMANN'S complaint was submitted in 1850, do not concur.

I observe that, in November 1854, JOHN SIMON HOLLAND obtained a patent for 'shells made with small segmental pieces of metal, closely packed in layers between the outer case and the bursting charge.' See *Abridgement of Specifications, &c.*, p. 186.

wooden ships, and the most formidable in range and effect.'[1]

Mr. Whitworth, in the course of a discussion at the Institution of Civil Engineers in February 1860, intimated that a similar effect is produced in shell fired from his own gun, by *scoring* the iron tube in segments internally, instead of building it up, on the plan adopted by Sir William Armstrong, of distinct pieces cemented by lead. When fired, a shell so prepared was broken into 'any desired number of fragments, according to the grooves inside; and the size of these fragments could be regulated so as to render them effective projectiles.'

The field-carriage of the Armstrong gun shows as much ingenuity as the gun itself, for in addition to an improved form of the elevating screw, there is a *horizontal* screw which enables the gun to be turned in 'azimuth,' as an astronomer would say, and with all the precision of an astronomical instrument.[2] The first guns made by Sir William were fitted up with a 'recoil slide,' up the inclined plane of which the gun glided when fired, descending to its original position by its own gravity after each discharge. This was afterwards abandoned in field-pieces, but was used in the navy, where it is a point of great importance that a breech-loading gun should be self-acting in this particular, to obviate the employment of hands in running it out.

'To these,' says a writer of that period in the *Edin-*

[1] *Report, &c.,* p. 8.

[2] *Edinburgh Review,* April 1859, p. 531.

burgh Review, 'are added several minor adjustments which are tedious to describe, but the result of which is, that from being the rudest of weapons artillery has been advanced to be nearly on a par mechanically with the steam-engine or the power-loom; and it differs as essentially from the old cast-iron tube dignified with the name of a gun, as the railway train of the present day differs from the stage-coach of our forefathers.'[1]

The workmanship and material of the gun first submitted to the Government were pronounced by the War Office authorities to be 'so superior that nothing equal in these respects could be looked for in the ordinary supply'[2] from the Royal factories; and its performance as far surpassed that of its predecessors, as it excelled them in ingenuity. Whilst the range of the old pieces could not be relied on beyond 1,000 yards, if so far, the Armstrong 32-pounder made good practice at 2,000 yards, and with a charge of 5 lbs. of powder, threw shot and shell upwards of *five English miles.* From a distance of 1,000 yards it pierced a bulk of elm three feet thick, and in one instance sent a bolt 400 yards beyond it after passing through the timber. As compared with an ordinary 9-pounder field-piece, the mean difference of range in the Armstrong was as 23 yards to 147, and the mean lateral deviation 0·8 of a yard compared to 9·1 yards; 'in other words, the Armstrong could hit a target 2 ft. 6 in.

[1] *Edinburgh Review*, April 1859, p. 532.

[2] *Report of the Ordnance Select Committee to the Secretary for War*, July 14, 1855.

in diameter at 1,000 yards, whilst the service gun could not be relied on to hit a haystack.'[1]

The Secretary of State for War, General Peel, when describing the performance of the Armstrong gun in the House of Commons in the session of 1859, said its 'accuracy at 3,000 yards was as *seven* to *one* compared with that of the common gun at 1,000; whilst at 1,000 yards it would hit an object every time which was struck by the common gun only once in fifty-seven times; so that at equal distances the Armstrong gun was *fifty-seven* times as accurate as our ordinary artillery.'[2]

[1] *Edinburgh Review*, April 1859, p. 529.

[2] General PEEL, *Speech in the House of Commons*, March 4, 1859.

CHAPTER III.

THE WHITWORTH GUN—ADOPTION OF THE ARMSTRONG GUN BY THE WAR DEPARTMENT.

WITH the completion of the Whitworth rifle, as described in a previous chapter, its author, strong in his conviction as to the truth of the principle on which it was formed, felt conscious of having possessed himself of a system susceptible of extension to ordnance of the largest calibre not less than to muskets of the smallest bore. As MILTON says, apropos of his own theory of the discovery of artillery, the origin of which he ascribes to the real hero of his grand epic,—

> The invention all admired; and each, how he
> To be the inventor missed:—so easy it seem'd
> Once found, which yet unfound, most would have thought
> Impossible.[1]

Allusion has already been made [2] to the circumstance that pending the rebuilding of his shooting-gallery, which was blown down by a hurricane in the winter of 1854, he had occupied his attention with the making of a rifled gun in segments, on a plan resembling that on which the earliest cannon were built up

[1] *Paradise Lost*, b. iv. v. 496.

[2] See *ante*, Part I. chap. iii. p. 36.

with bars secured by hoops of iron. Besides what was gained in portability by this mode of construction he hoped to attain superior facilities for restoration and repair; since the gun could be taken to pieces, and the dimensions of each part being accurately determined by gauge, any individual piece could be replaced in case of injury; nor would the whole be any longer liable to be rendered useless by the wearing out of the touch-hole. This idea he never fully matured, his attention being absorbed by the pressing necessity of improving the Enfield musket, to which he applied the formula of polygonal rifling, originally intended to be embodied in the segment gun.

Between the years 1854 and 1857, he was repeatedly solicited by the Commander-in-Chief and the Master-General of the Ordnance to extend his attention to artillery; and brass blocks were supplied to him from the Royal factory, 6, 9, and 12-pounders, which, at the request of the Government, he rifled polygonally. These guns having been tried in succession by the military authorities at Shoeburyness, were each and all reported on favourably; and when Lord Hardinge, accompanied by General Hay, the chief of the School of Musketry at Hythe, visited Manchester in the spring of 1856, to be present at Mr. Whitworth's trials with the new rifled musket, he was so struck by its extraordinary performance that he expressed his wish that Mr. Whitworth should proceed to apply to *heavy ordnance* the same system of rifling which had proved so singularly successful in small arms.

Blocks for three brass 24-pounder howitzers, cast solid in the Royal factory at Woolwich, were accordingly sent down to Manchester to be bored and hexagonally rifled. Of these one was sent for trial to Shoeburyness, where its performance was at that time regarded as something remarkable. With a charge of $2\frac{1}{2}$ lbs. of powder, and at an elevation of $14\frac{1}{2}°$, it sent an elongated projectile a distance of 3,240 yards. Another was fired on April 14, 1857, in the grounds attached to Mr. Whitworth's residence near Manchester; and a few weeks after the same gun, in order to test its range, was again tried in presence of military officers deputed by the War Office, on the sands to the north of Mersey, a few miles from Liverpool. Up to that time, according to Sir Howard Douglas, the ordinary range of a 24-pounder with a charge of 8 lbs. of powder fired at an elevation of 8°, was 2,200 yards;—Mr. Whitworth's rifled gun, with a charge of only $2\frac{1}{2}$ lbs. of powder, fired at an elevation of $8\frac{1}{4}°$, sent a shot of 24 lbs. to a distance of 3,500 yards, being nearly *two miles*. This range so far exceeded anticipation that sufficient caution had not been exercised in selecting a locality free from obstruction; and the shot, after striking the sand, ricochetted to the right of the line of fire, and entering a marine villa, north of the village of Waterloo, it rolled upon the carpet, fortunately doing no greater damage than demolishing the window and astonishing a lady who was seated near the drawing-room fire.

In November 1857, the third 24-lb. howitzer, which

had been sent to Portsmouth for practice on board the training ship the 'Excellent,' fired shot of a peculiar form, which will presently be described,[1] which successfully displayed the singular property of maintaining its direct course *under water*, and penetrating eight inches of oak, three feet below the surface; an exploit previously held to be impossible.[2]

In the course of two years Mr. Whitworth, at the request of the Government, rifled in all seven brass guns of different calibres; the blocks in every instance being provided for him from the Royal founderies. In each of these instances the system applied was the same in 1856 and 1857 as that used by his firm at the present day; the rifling and its pitch were almost alike, and the projectile was the same, with the exception that the rear has since been tapered in order to increase the range and steadiness of flight; whereas at first it was carried parallel throughout.[3] The gun was a muzzle-loader; and its excellence was the result of the same combination of conditions which had already imparted surpassing excellence to the Whitworth rifle.

Hitherto he had acted in friendly concert with successive Secretaries of State, and in cordial co-operation with the War Department, but in the year 1858 a conjuncture arrived, the consequences of which were calculated to change that confidential relation. The period is still so recent as to render it super-

[1] See *post*, Part III. chap. iii. p. 251.

[2] Sir Howard Douglas, *Naval Gunnery*, p. 423.

[3] Mr. Whitworth's *Evidence*, *Report of the Select Committee of the House of Commons on Ordnance*, 1863: 2,509, 2,577.

fluous to recall the remembrance of that apprehension of foreign invasion, which disquieted this country in the years 1858 and 1859, and even down to a later time. France was believed to be contemplating a descent upon our shores; encouraged by the knowledge, which it was scarcely possible to withhold, of our utter unpreparedness for any sudden attack. The Duke of Wellington, some years before, in a letter which he addressed to the Inspector-General of Fortifications, Sir John F. Burgoyne, had pointed out in detail the defects of our position, and the danger to which they exposed us. That letter, notwithstanding the confidential nature of its contents, had by some means obtained publicity, and it naturally served to increase the sensitiveness of the public mind.

Shortly after the close of the Russian war there was evidence of unusual activity in the French arsenals and dockyards; where not only iron-clad ships were in process of construction, but vessels of suspicious build were being prepared, calculated for the landing of cavalry and troops. Startling reports were in circulation respecting the improvements then made, not only in the rifle for the line, but in rifled cannon both for field and sea service. The tone of the French press was exasperated and sullen; and the 'Colonels' in the French army despatched angry and excited addresses to the Emperor, clamouring to be led to the sack of London.

In spite of the warnings of the Duke of Wellington, the measures adopted for national defence against such a calamity had made but tardy progress. The great

naval arsenals were imperfectly protected, and the numerous commercial ports and harbours around the coast were utterly destitute of defence. Even if fortifications had been constructed, there were not forces to garrison them, nor a movable army sufficiently strong to encounter an invading enemy. In this emergency unusual earnestness was displayed in embodying militia, in training local artillery, and in raising and organising volunteers in every district of Great Britain.

The measures adopted by the War Department for the production of the Enfield rifle, had placed at the disposal of the Government a rifled small arm of highly-improved construction; but up to that time the question of rifled ordnance, and the means of obtaining an adequate supply of artillery of ascertained excellence, both for the army and the navy, although eagerly discussed, had not as yet arrived at any practical solution. Lord Hardinge, to whom the country was so much indebted for originating and sustaining the movement for improvement of rifled arms, had retired from the army and died; and although the spirit which he had infused into the military departments had not declined, operations had been impeded by the change of ministers, and the new organisation of departments, by which the War Office was separated from the professional administration of the army. Meantime the various models of rifled cannon, alluded to in a previous chapter,[1] had been submitted by their inventors between 1855 and 1858. The Armstrong gun had been brought before the Duke of New-

[1] See *ante*, Part II. chap. i. p. 83.

castle in 1854, and its performance drew from Lord Panmure a highly laudatory notice in 1858. Mr. Whitworth's rifled cannon had also been tried, and reported on favourably, on several occasions in 1856 and 1857; but still no final decision had been come to in relation to any of those offered.

The subject had become one of serious interest; and public anxiety was aroused by events occurring in rapid succession. The Crimean war was just ended, but the most formidable revolt on record was still desolating India, whilst England herself was being menaced along the line of her own shores. The question of ordnance engaged the early attention of the Earl of Derby and his Cabinet; and in August 1858, General Peel, Secretary of State for the War Department, 'finding that the subject was not making head,'[1] and that other countries were taking the lead of Great Britain, directed a report to be forthwith prepared of the results obtained up to that date, in the trials that had been made of the several cannon tendered for adoption into the service.

A summary was accordingly drawn up by Colonel Lefroy, who then occupied a confidential position as scientific adviser to the Secretary of State on matters connected with artillery. In this document Colonel Lefroy represented that the prospect, as regarded large guns for fortifications or ships of war, was not so encouraging as that for field guns, which might eventually be

[1] *Evidence of* Col. LEFROY before *the Ordnance Committee of the House of Commons*, 1862; 364, p. 16.

obtained with less difficulty. The Armstrong, he said, though one of the most effective hitherto brought forward as a light gun, was probably incapable of being made of large calibre, from its expensive character, as well as from the nature of the projectile. Whitworth's 32 and 68-pounders afforded great facility of loading, with promise of great accuracy; and the field-guns on his principle had succeeded remarkably. Garrison guns, both on Lancaster's, Blakeley's, Cavalli's and Baron Wahrendorf's systems, were each in some particulars objectionable. Colonel Lefroy was, however, on the whole, of the opinion that 'almost every element was wanting on which to base a decision as to the adoption of any one system,'[1] and he recommended the immediate appointment of a *Committee on Rifled Guns*,[2] with instructions to examine, with the least possible delay, all the heavy rifled guns extant, and to render a detailed account of their respective performances and capabilities for garrison and naval service.

A few days after the receipt of this Report, General Peel acted upon the suggestion of Colonel Lefroy, and in August, 1858, nominated a special committee, to ascertain the best form of rifled gun offered up to that time, not for garrison service only, but for field service as well.

[1] See Col. LEFROY'S *Report*. Appendix to the *Evidence* taken by the *Committee of the House of Commons on Ordnance*, 1862, p. 147.

[2] August 30, 1858. The members were Colonel MITCHELL, R. A. *President*, Sir WILLIAM T. WISEMAN, R.N., Colonel W. J. SMYTHE, R.A., Major WEMYS, R.M.A., Colonel D'AGUILAR, who resigned, and was succeeded by Captain R. J. HAY, R.A., and Captain ANDREW NOBLE, R.A., *Secretary*.

Having been directed to proceed 'as speedily as possible,' the committee furnished their report within less than three months.[1] In it they stated that, of the *seven* guns offered for their consideration, they found that *five* presented so little superiority over the old smooth-bore, that they could not recommend them for further experiment. The attention of the committee was consequently concentrated on those of Mr. Armstrong and Mr. Whitworth; and it appears that the experiments with the latter, were not of so extended a character as those with the former; probably, because up to that time Mr. Whitworth had only acted under the orders of the Government in rifling blocks supplied from the Royal founderies; whilst Mr. Armstrong, in addition to rifling, submitted likewise a system of his own invention for constructing a gun with a form of projectile, and an arrangement for loading, all peculiar to himself.[2]

After a very few trials with the Whitworth gun, at which Mr. Whitworth states that he had had no opportunity given to him to be present;[3] the Select Committee reported that they found the projectiles had a large and rapidly increasing deflection to the right, which obstructed accuracy of aim; and that the shot and shell used with the gun gave different ranges and different degrees of accuracy; that of the shot being greater

[1] Dated Nov. 16, 1858. It is appended to the *Report of the Select Committee of the House of Commons on Ordnance*, 1862, p. 166.

[2] *Report of the House of Commons' Committee on Ordnance*, 1863, p. 4.

[3] *Evidence, Ibid.* 2,416–7.

than that of the shell. The shot, too, were so liable to 'jam' in loading that very careful washing and drying of the gun were indispensable after every round; and, although Mr. Whitworth had overcome this by the use of lubricating wads, which 'appeared to answer well,' further trials were necessary to determine their sufficiency to enable washing to be dispensed with.

On the other hand the committee reported that two of Mr. Armstrong's breech-loading rifled guns (an 18-pounder and a 12-pounder) exhibited powers of range and precision quite extraordinary, whilst his projectile was capable of being used either as shot, or Shrapnell shell, in which latter capacity the destructive effect appeared 'to exceed that of any shell in the service.' Mr. Armstrong also laid before them a percussion arrangement for fuses, of great importance. Both in range and penetration the committee represented the practice of the 18-pounder Armstrong gun as 'probably the greatest on record,' although it had since been exceeded by his 32-pounder, which attained the astonishing range of 9,175 yards.[1] In the case of the Armstrong

[1] This has since been surpassed by the guns of Mr. WHITWORTH, whose small 3-pounder gave a range of 9,600 yards and upwards; and his 12-pounder one exceeding 10,300 yards, being very little short of *six miles!* Lord HERBERT, on one occasion, undertook that Sir WILLIAM ARMSTRONG should produce a gun made expressly for range, which should surpass anything exhibited by Mr. WHITWORTH: this pledge has not yet been redeemed, but on the contrary, Sir WILLIAM, at the Institution of Civil Engineers in 1860, stated that 'although the public is always captivated by the attainment of long ranges, a great delusion prevailed on the subject;' such extreme distances rendering accuracy of aim impossible, so that the fate of a battle, however perfect the weapon might be, could never be decided by firing from them.—*Minutes*

gun the employment of water was necessary to remove the fouling; and when first adopted, the working on this account was attended with serious inconvenience. Such, however, was their facility of loading, their accuracy, and apparent durability, that '*the Committee on Rifled Cannon recommended the immediate introduction of guns rifled on Mr. Armstrong's principle, for special service in the field.*'

This Report bears unmistakable traces of the urgency and speed with which the members conducted their enquiry, and probably to this cause is to be ascribed an omission, much to be regretted, since it has since afforded ground for complaint by Mr. Whitworth on the score of precipitancy, and of inadequate examination into the merits of his gun, as compared with the attention bestowed upon the competing one. The committee at the outset of their labours had felt the importance of visiting in person the respective factories of Mr. Armstrong at Elswick, and of Mr. Whitworth at Manchester, accompanied by a practical officer, Mr. Anderson, the Inspector of Machinery at the Royal Arsenal. Their object was to examine the pro-

of Pro. Inst. Civil Eng. on Construction of Artillery, p. 124. His earlier convictions would seem to attach a higher value to range; and in his Report to the Secretary for War on Rifled Guns in 1855, he illustrated its importance by the incident which chiefly contributed to direct his attention to the subject of rifled artillery. 'I allude,' he there says, 'to the memorable service rendered at Inkermann by means of the two 18-pounders, directed against the Russians, *at a distance from which the numerous but light guns of the enemy could not reply.*' It may be observed that the two other great battles of the present decade, those of Magenta and Solferino, were mainly won by the range of the French *Canons rayés*; but these were fought at distances which were doubtless within the '*extreme*' range, the attempt at which Sir WILLIAM dissuades.

cesses and modes of manufacture of each, and thus to ascertain on the spot those particulars and peculiarities which might enter largely into the question of comparative excellence. They arranged to go first to Elswick, which they did; and a time was also fixed to visit the works at Manchester. But that Mr. Whitworth has expressed himself aggrieved, that although anxious to avail himself of that occasion for fully explaining his process, and showing what he had already done, as well as what he was further prepared to do, he was deprived of the opportunity; as the committee *never made their promised visit to his works, but reported in favour of a competing system without duly examining his.* In a letter to the *Times*[1] he complained that the committee of 1858, 'without performing their promise to visit his works and see what was being done there; and without affording him an opportunity to be present at the comparative trials of his gun, when he would have shown them what it could do; and without even giving him information as to the results obtained in his absence, should have come to a decision against it—a result which came to his knowledge by accident afterwards.' He felt that facilities had not been granted to him which were accorded to his rival; and that he had not, as Sir William had, opportunity given for applying on the spot expedients to remove temporary difficulties.

It is possible that in making the omission complained of, the committee may have been influenced

[1] October 11, 1862.

by the tenour of their instructions enjoining the utmost possible speed; or that, already satisfied of the sufficiency of the Armstrong gun, or even convinced of its superiority over those produced at that time by Mr. Whitworth, they may have felt it superfluous, after examining the works at Elswick, to occupy more time by proceeding to those at Manchester.[1] But apart from

[1] Before the *Committee of the House of Commons on Ordnance*, which resumed its sittings in 1863, Sir WILLIAM WISEMAN, Bart, R.N., gave an explanation of the course pursued by the Committee of *1858*, of which he was a member. He stated that in order 'to obtain complete information upon the subject referred to them, it was quite clear to them that there were only two systems of rifling with respect to which it was advisable to go into lengthy or expensive experiments, which were Mr. ARMSTRONG's and Mr. WHITWORTH's; and that letters were directed to be written' to these gentlemen and another, Mr. LANCASTER. Sixty days at least were occupied in experiments, 'almost entirely between the Whitworth and the Armstrong guns.' 'At first,' he adds, 'we thought it would be necessary to visit both Sir WILLIAM ARMSTRONG's and Mr. WHITWORTH's manufactories, in order to ascertain their method of manufacturing guns; but we only visited Mr. ARMSTRONG's *because we had no proposal from Mr. WHITWORTH before us, for constructing guns at all*' (122, 123, 127, 145). There is some obscurity in this, as it is not quite intelligible that 'no proposal of a gun by Mr. WHITWORTH' should have been before the Committee; when both in the report of the Committee and in this evidence of Sir WILLIAM WISEMAN, it is implied that of all those guns which they were bound to examine, they included *two only* in the first class; namely, those of Mr. ARMSTRONG and Mr. WHITWORTH, regarding all others as valueless in comparison with them.

Sir WILLIAM WISEMAN goes on to say that the Committee did experiment with a gun rifled on Mr. WHITWORTH's principle, a 9-pounder taking a 12-pound projectile, but they '*came to the conclusion* (having, in fact, no other gun before them save the brass guns rifled on the hexagonal principle) *that Mr.* ARMSTRONG's *gun was superior to all others*, and recommended its adoption for field service. . . . Mr. WHITWORTH *was informed by the War Office* that the Committee were going there;' but Sir WILLIAM thinks 'they had no other communication with him.' On this part of the case his information seems to be imperfect. The

any question as to the amount of evidence excluded, an oversight was thus committed, such as served to impair confidence in the results of the enquiry, and to justify a doubt in the mind of Mr. Whitworth as to the soundness of the decision arrived at.[1]

The Secretary of State for War acted promptly on the recommendation of the committee, and the light Armstrong gun was adopted for field service in November

arrangements for visiting Mr. Whitworth's works were not only express, but were made at the request of the Committee. On September 20, 1858, Lord Hardinge wrote, by direction of General Peel, to say that the Committee having expressed a desire to visit Mr. Whitworth's works, he had to ask that the necessary facilities might be afforded them for that purpose. Mr. Whitworth, in reply, signified the pleasure with which he would do so at any time they might think fit to come to Manchester; and Colonel Mitchell, in answer, said the Special Committee would acquaint Mr. Whitworth with the time so soon as they could arrange it.

There is probably some confusion in reporting this explanation of Sir William Wiseman, which is not satisfactory as regards this portion of the Committee's proceedings; and in a further stage of his evidence, whilst eulogising the range and accuracy of Sir William Armstrong's guns, he frankly avows that 'from what he has seen of Mr. Whitworth's, *he thinks his guns are quite equal;* but he has had very little opportunity of seeing them' (280–281), and so few of the Whitworth guns have been tried, as compared with the Armstrong, that '*he cannot say as yet that we have been able to judge.*'—(539.)

[1] Colonel Lefroy, when questioned by the *Committee of the House of Commons on Ordnance*, in 1860, as to whether the Select Committee of 1858, after 'visiting the Elswick works, and conferring with Mr. Armstrong there regarding his guns, had gone to Mr. Whitworth's works and considered his inventions in the same way,' made reply that 'Mr. Whitworth at that time made so great a secret of his mode of rifling, that the Committee would have got nothing by going to him.' This answer is unsatisfactory; opposed as it is to the fact that Mr. Whitworth had written at the time both officially to the Secretary of State, and unofficially to the President of the Committee, Colonel Mitchell, to communicate *information, and to express his satisfaction* at the prospect of receiving them at his works.

1858,—but foreseeing the possibility that 'another and superior gun' might be discovered, General Peel wisely directed that the suitability of those of heavier calibre for fortifications and for the navy should be left for future consideration. Lord Derby likewise enjoined caution; and in a letter addressed to General Peel on December 18, 1858, said that 'he should rather doubt the expediency in the present infancy of the invention, and when doubtless time and experience will both suggest improvements and produce economy in manufacture, of pressing for the immediate supply of a large number of guns, of the first type and at the highest rate. He also suggested that the first orders should be confined chiefly, if not exclusively, to that class of guns, say 32-pounders, of which we have had sufficient proof, and that we should defer any order for heavier guns till they had been rather more tested.'[1]

On the decision being made known, Mr. Armstrong was applied to, to state on what terms he would be ready to transfer his discoveries, and the patents which protected them, to Her Majesty's Government. To this he replied by declining to negotiate on the basis of a purchase; but expressed his readiness to assign them unconditionally, being desirous and preferring to make them a gift to Her Majesty and her successors 'without any pecuniary or other valuable consideration.'[2] A deed

[1] *Select Committee of the House of Commons on Ordnance*, 1862, p. 112. *Ibid.*, 1863, *Report*, p. 4.

[2] Sir WILLIAM ARMSTRONG, who on principle is an opponent to the system of all patents, stated to the *Committee of the House of Commons on Ordnance*, 1863 (5,010) that 'he never attached any value to the

to that effect was accordingly executed on January 15, 1859, thus completing what General Peel, in communicating the fact to the Earl of Derby, described as 'the handsomest offer ever made by a private individual to the Government.' Mr. Armstrong was paid by grants from the Treasury, in reimbursement of all expenses attendant on his experiment between the years 1855 and 1859, when his gun was adopted.[1]

But a difficulty arose on the very threshold; the gun, whatever its excellence, *was still incomplete*, and no one but its inventor was competent to conduct the further experiments requisite to render the invention more perfect. It was, as Sir William Armstrong subsequently said, 'a special manufacture, known at that time only to himself; and the Government, after they had obtained a grant of these inventions, had no means of putting them in practice, except under his direction.'[2] Within three days, therefore, from the signature of the deed by which he so generously made over his interest in the patents, he, on January 18th, 1859, addressed a further communication to the Secretary of State in which he made a suggestion as to a return for his exertions, since he could not engage to give up gratuitously all future as well as past inventions

patent of his gun; and Mr. Anderson, his assistant, added on the same occasion, 'there is no secret in it.' (*5,555.*) The Secretary of State for War, however, declined to submit the patent itself to the Committee, as being contrary to 'public policy.' (5,078.)

[1] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1862, p. 17.

[2] *Evidence of the Select Committee of the House of Commons on Military Organisation*, 1860; 7,378, p. 513, 7,414, p. 515.

connected with the subject. His proposal was that he should give his future services, in the capacity of a public officer, at an adequate salary, and with the title of *Director of Rifled Ordnance.* 'With regard to the past,' he continued, 'considering that I have waived, for the public benefit, rights which I might have turned to great pecuniary advantage,[1] I conceive I am entitled to some public acknowledgement. I feel that I cannot claim the merit of a gift, and at the same time expect a pecuniary equivalent, for the value of what I have relinquished; but I think, that, without involving any inconsistency of this kind, some requital might be made for the mere time I have expended upon the subject for the last three years; and I should, therefore, propose that the salary to be affixed to the new office should date back from the commencement of that period. With regard to the amount of that salary—I may fairly estimate the entire value of my time, in a professional point of view, at 6,000*l.* per annum; and I should consider that fully half that time would be absorbed in performing the duties of the supposed office. I would, therefore, propose 3,000*l.* a year, a proper amount to cover services and future inventions.'[2]

This proposal of 3,000*l.* per annum, he modified by reducing it to 2,000*l.* a year, with the under-

[1] From the evidence given by General PEEL before the *Select Committee on Ordnance* in 1862, it seems doubtful whether such a patent had been taken out by Sir WILLIAM ARMSTRONG as would have secured to him the exclusive right of manufacturing guns on the plan proposed by him.—*Evidence*, p. 214.

[2] *Appendix to the Evidence of the Select Committee of the House of Commons on Ordnance*, 1862, p. 256.

standing that retrospectively it was to date backwards so as to include arrears for three years past, and prospectively that it was to endure for seven years to come. In addition to his official duties, he was to remain at liberty to carry on his private business at Elswick as heretofore, or any other in which he might think proper to engage.[1] With these terms the Secretary for War complied, convinced, he said, that to take his patents, without securing his services in the making of the gun, would be useless;[2] and Mr. Armstrong was accordingly appointed *Engineer to the War Department*, on February 23, 1859, with an income of 2,000*l.* per annum, and travelling expenses not exceeding 800*l.* a year; — his salary to be calculated retrospectively from 1856, as some compensation for the labour and outlay he had incurred.

As his functions were to be consultative and directory, he was at the same time provided with an Assistant, Mr. Anderson, to take charge of the practical department at Woolwich. The functions of Mr. Armstrong (who on his appointment, received the honour of Knighthood and the Companionship of the Bath,) were defined in an official minute, by which he undertook to give his best attention to *maturing* and *perfecting* his gun, and to conduct all *experiments* and *investigations* for *developing his system*, and for the improvement of rifled ordnance generally: — and all

[1] *Appendix to the Report of the Committee of the House of Commons on Military Organisation*, p. 662.—*Evidence*, 7,414, p. 515.
[2] *Committee on Ordnance*, 1862, p. 112.

patents taken out by him for these purposes were to be the property of the crown. He was to furnish designs and drawings for guns, to visit the establishments for making those designed by himself, and to direct the processes; but without the responsibilities or duties of a resident superintendent.[1]

At a later period Sir William Armstrong received the further appointment of '*Superintendent of the Royal Gun Factory*' at Woolwich.

Simultaneously with the transfer of his interest in his patents, a contract of an important character was entered into for the manufacture of his guns, by a private company, upon highly advantageous terms. This contract was made on the same day (January 15, 1859) on which Sir William Armstrong signed the deed of assignment to the crown; and the parties to it were the Secretary of State for War, Sir William Armstrong, and Sir William's partners, who formed what has since been known as the *Elswick Ordnance Company*,[2] in which they were joined at a later period by Captain Andrew Noble, of the Royal Artillery, a gentleman whose services as Secretary to more than one of the Select Committees on Ordnance had rendered him

[1] Mr. Anderson, in 1860, stated in reply to a question addressed to him by the *Committee of the House of Commons on Military Organisation*, as to the relative positions of Sir William Armstrong and himself, that he 'looked upon Sir William as his superior; at the same time, he does not interfere with the manufacture at all—he confines himself altogether to the gun and to the development of the gun.'—7,564, &c., p. 415.

[2] *Report of the Select Committee on Military Organisation*, 1860, pp. xvii, xviii.

thoroughly acquainted with the properties of the Armstrong gun.

It is probable that in coming to this arrangement with the Elswick Company, the Government contemplated the possibility of the Royal factory at Woolwich being unable in sufficient time to meet the demand which was then so urgent for artillery;—but the reason ostensibly assigned for creating this special establishment was that the Armstrong gun was of so peculiar a construction, and so much depended on the mode of putting it together, that it was represented to be unwise to get them in the open market, or to entrust the manufacture to ordinary contractors,[1] as had been the practice of the Government at former times in getting cast-iron guns from the foundries at Gospel Oak and Low Moor. This alleged peculiarity in the Armstrong gun was in itself a grave objection to an article which frequently required to be furnished in large quantities, and occasionally at very short notice. To overcome it the arrangement alluded to was made with the individuals named, whereby the exclusive right of supplying rifled ordnance beyond those made at Woolwich was given to the Elswick Company, with a guarantee for full and constant employment.

To this Company Sir William Armstrong furnished capital at a fixed interest, reserving to himself the right to join it in the event of his retirement from

[1] *Report of the Select Committee of the House of Commons on Military Organisation*, p. xvii.

the public service.[1] And as the manufacture was of so novel a character as to render it impossible beforehand to calculate the probable cost with precision, it was understood that the question of fair prices for any work done for the Government was to be a subject for future arrangement.

Another contingency was also provided for;—regarding the extent of employment to be given by these contracts, as liable to fluctuation and its continuance uncertain; it was stipulated that in the event of the Government curtailing or withdrawing their orders, so as to leave the works at Elswick either wholly or partially unproductive, compensation, not exceeding *85,000l., was to be paid in respect of so much of the* capital as might be invested with the previous sanction of the Secretary of State. To the latter condition the Earl of Derby and General Peel were induced to assent, inasmuch as the guarantee was only to be enforced *in case of actual loss*; such as might accrue in the event of a superior gun being discovered, or of Government transferring the entire manufacture to Woolwich.[2] General Peel also considered that the

[1] *Evidence of the Select Committee of the House of Commons on Military Organisation*, 1860.—7,414, p. 515.

[2] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1862, p. 112. The caution enjoined by Lord Derby is evinced in the following passage, a letter from him to General Peel, dated Knowsley, December 18, 1858. 'There can, I think, be little or no doubt of the immense superiority of Mr. Armstrong's guns over everything yet invented, and his mode of dealing with the Government has been very fair and reasonable. I am not, however, sure that I understand the precise effect of the guarantee for which he asks. That which we have already given is that 'he shall not be a loser' by the

guarantee had reference to guns alone, and did not extend to the manufacture of projectiles.[1]

The Elswick Company was thus erected into a close and privileged monopoly; but it was of course interdicted from making guns on the Armstrong principle for any party other than the Government; and the Government, on their side, consented to make advances on account of work ordered and in process of manufacture.

Whatever may appear objectionable in the details of this arrangement, must be accounted for by the fact that the extraordinary crisis at which it was entered into, was one that required an extraordinary expedient to tide it over. This, and another anomaly in relation to the system of official inspection, are summed up in the 'Report of the Committee of the House of Commons appointed in the Session of 1860, to enquire into the effects of the Alterations in Military Organisation, made in the year 1855.' This Report which was drafted by the chairman, the late Right Hon. Sir James Graham, stated that, 'The construction of the Armstrong guns is a very refined process. The putting together requires to

expenditure of 12,000*l.* on a plant which will enable him to turn out 100 guns a year, at an estimated cost of 40,000*l.*; or, in other words, that we will give him sufficient employment to reimburse him that sum over and above a fair and reasonable profit. It is not very clear to me how this fact is to be established, or how soon the guarantee is to be exhausted; but I think it should be more explicitly settled when you come to make your final arrangements with him, which, I quite agree with you, should be fully set forth in writing.'

[1] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1862, pp. 30, 112, 113.

be carefully done. Mr. Anderson, Sir William's assistant at Woolwich, deposes that if these guns were made by contract, it would be necessary to have some *inspectors* constantly at the place where they are made, as no inspection *after* they had been put together would be satisfactory. Yet these guns are made at Elswick —they come up from Elswick put together. There is no Government inspector at Elswick to watch their construction, but Sir William Armstrong says that the guns are manufactured there *under his own inspection*, and that he goes down continually. But at Woolwich also there are 3,000 men at work under his superintendence, and he admits that at Elswick *he inspects guns made by his own partners* in a neighbouring concern.'

'*Sir William Armstrong is well worthy of confidence; and has acted generously towards the public by the free surrender of his patent rights; but he is placed by these arrangements in a false position. He cannot watch two great concerns distant from each other more than* 300 *miles. He ought not to be inspector of the work of his own partners, although the guns are proved by an artillery officer on their arrival at Woolwich. This large and exclusive manufacture is proceeding on the assumption that they are proved to be the best. But Mr. Anderson admits there would be a difficulty if Mr. Whitworth's guns were proved to be better*.'[1]

[1] *Report*, &c., p. xvii. See also the evidence of Mr. ANDERSON, 7,425, 7,442, 6,067–8, 6,072–3, 7,445–6–7.

The Elswick Company commenced the manufacture of guns for the Government in January, 1859. The orders were then confined to the field-pieces previously taken into the service; but in the following autumn guns of larger calibre, the consideration of which had been very properly deferred by General Peel (who was no longer in office), were accepted for the naval service, their adoption having taken place under the circumstances thus succinctly stated in the *Report of the Committee of the House of Commons* reappointed in 1863 to enquire into the expenditure on rifled ordnance.

'In the winter of 1858–9, the Board of Admiralty, acting upon the advice of Captain Hewlett, R.N., of H.M.S. *Excellent*, gunnery ship at Portsmouth, decided upon the introduction of the Armstrong guns into the navy for boat service; and in the summer of 1859, the same officer having urged the importance of introducing into the navy larger calibres of Armstrong guns, the Board of Admiralty requested the Secretary of State for War, in the strongest manner, to supply them with as little delay as possible with a large number of 40-pounder and 70-pounder Armstrong guns.[1]

'On September 24, 1859, a committee, *of which Sir William Armstrong was a member*, approved of the pattern of the Armstrong 40-pounder for naval service. The Armstrong system was first extended to the 110 calibre on October 14, 1859. The political necessities of the day appear to have been so urgent as not to allow time for maturing the design previous to its manufac-

[1] *Report*, 1862, Appendix, p. 246, 247. *Ibid.* 1863, p. v.

ture. In consequence of the excessive pressure which existed at that time for the supply of guns of that calibre, the first 100 of these were constructed *before any experiments upon them had been concluded.*[1]

'At the same time, careful and extensive experiments were carried on, to test whether any safe system of strengthening cast-iron guns could be found, or whether any better, speedier, or cheaper system of constructing rifled guns existed than that proposed by Sir W. Armstrong.[2] None such having been found within the period for enquiry, the Armstrong system was completely adopted by the Government.'

[1] See the narrative of Sir WILLIAM ARMSTRONG. *Evidence &c.* 3,163. p. 136.

[2] *Ibid. Evidence* 1863, 5,230, 5,233-4. *Evidence* 1864, 177, *et seq.* 2,763, 2,765. *Ordnance Report* App. (1862) p. 207. *Report of Ordnance Select Committee on Cast Iron Ordnance, Parliamentary Paper,* 1863.

CHAPTER IV.

EFFECT OF SIR WILLIAM ARMSTRONG'S OFFICIAL RELATION TO THE WAR DEPARTMENT.

THE recent retirement of Sir William Armstrong[1] from his official employments—his tenure of which had been discussed by the Committee of the House of Commons, appointed in 1860, to enquire into the effects of certain changes in Military Organisation—has relieved the question of his original appointment from much of that delicacy and reserve with which we must always speak of a man of his high character and distinguished abilities, in relation to whatever position he may have been called to fill in the public service. But irrespective of Sir William Armstrong's eminent talents and qualifications; entirely apart from the merits of his gun and without impugning in the remotest degree the views and intentions of the Government by whom he was elevated to that high rank in his profession; subsequent experience has demonstrated that, consistently with the public interests, and with the advancement of the great and paramount object which was the impelling motive of his original appointment—namely, the improve-

[1] In February, 1863.

ment, not of his own gun alone, but of rifled ordnance in general, *that appointment was one which ought never to have taken place.* The French and other governments equally earnest in the same pursuit as ourselves, have manifested more caution, and whilst encouraging all to exertion for the improvement of rifled ordnance, have prudently forborne to commit themselves to any peculiar system or to any individual inventor.

The circumstances under which Sir William Armstrong's field-gun was adopted in 1858; the complaints and protracted discussions to which it gave rise, ending in the recent appointment of another committee to re-consider the decision of the first — are all practical illustrations of the wisdom of the Duke of Wellington; in declining to embarrass the Government by identifying it with *unfinished experiments*, or by the premature admission into the service of any incomplete arm.[1]

The excitement of public feeling at the time, and the pressure of the many considerations before enumerated, serve to explain this departure from a wisely-established rule. Lord Herbert, who succeeded as Secretary of War on the retirement of General Peel in 1859, adopted and justified the act of his predecessor by declaring his own belief 'that, when the Armstrong gun was first adopted, it had no competitor; and that, if we had waited till the great question should have been decided, of what is the best possible gun to be made, it would not be

[1] See *ante*, Part I. ch. i. p. 12.

in this year, nor yet in the next, that we should commence to make that which all other nations had already got, and what we should then be without.'[1] The evidence of General Peel corroborates Lord Herbert's view of the exaggerated accounts of the Armstrong gun, by which persons were carried away in 1858;—one general officer told him '*There was nothing half so wonderful in the Arabian Nights*;' and the Duke of Cambridge, after witnessing its performance, said '*It could do everything but speak*!'[2] Long after General Peel's retirement from office, his successors retained an undiminished confidence in the field-gun which he adopted, and in the House of Commons in 1860, the Secretary for War renewed the assurance, that 'it had not been surpassed, if it had been equalled;' and that from Sir W. Armstrong, 'whatever happens, we shall have the best and most admirable weapon that can be made.'[3] *The Select Committee of the House of Commons on Ordnance Expenditure* in 1863, recorded their opinion that on a review of all the circumstances and the alleged superiority of the Armstrong gun to all others 'known at that time, its adoption by the Secretary of State for War, for special service in the field, was fully justified.'[4]

Amongst other circumstances that rendered decision urgent, was the mutiny then convulsing India; and for the suppression of which the Indian Government, with-

[1] *Evidence of the Committee of the House of Commons on Military Organisation*, 1860. 7,254, p. 505.

[2] *Committee on Ordnance*, 2,308, p. 111.

[3] Mr. S. Herbert, House of Commons, Feb. 18, 1860.

[4] *Report &c.*, p. 4.

out waiting for the report of the committee, anticipated the result, by applying to the War Office for a battery of Armstrong guns. Constrained by this combination of influences, General Peel gave his sanction to the recommendation; but it must also be remembered that the only gun, for the adoption of which he is responsible, is the light field-piece; which is still in esteem in the service, except amongst those who object on principle to breech-loading.[1]

The gun, however, was admitted to be imperfect in some respects, nor has Sir William Armstrong, either at that time, or since, ever advanced for it any claim to mechanical perfection. On the contrary, in the condition in which it was presented when it was examined by the committee, in 1858, it was avowedly only *in progress* towards efficiency. The first questionable step, therefore, involved the necessity of the second; inasmuch as the incomplete gun required the con-

[1] See *Report of the House of Commons' Committee on Ordnance*, 1863, p. vi; evidence of the Duke of CAMBRIDGE, 1,250, and of Colonel BINGHAM, 374, 524. The Earl of DERBY, in a letter to General PEEL, already quoted (p. 139 note) whilst signifying his approval of the Armstrong gun, dwelt upon the inexpediency '*in the present comparative infancy of the invention*, and when, doubtless, time and experience will both suggest improvements, and produce economy in manufacture, of pressing for the immediate supply of any very large number of guns, of the first type and at the highest rate:' above all, '*to defer* any order for *heavier guns* till they have been rather more tested. I have written,' his lordship concludes, 'to PAKINGTON, to say that in my opinion this invention strengthens the case against building overgrown three-deckers, and in favour of constructing line-of-battle ships of moderate dimensions. It will also, if I am not mistaken, give greatly-increased value to steam gun-boats, with which we are fortunately well provided.'

tinued attention of its inventor to render it complete; and hence the duties of Sir William Armstrong, as defined in his instructions, were at first confined to 'maturing and perfecting' his gun, and to 'conducting experiments for the purpose of developing his system.'[1]

Even on the supposition that his functions were confined to the improvement of *his own gun*, their exercise could hardly fail to produce inconvenience to the service, in a variety of forms; such as the cost of fresh experiments, the loss entailed by their failure, the delays incident to alterations, the multiplication of models (many of them eventually superseded), the interruptions in training and discipline resulting from frequent changes; and above all, the gradual undermining of confidence in the minds of those employed both in the land and sea forces, on perceiving that the arms with which they were provided, instead of being incontestably the best that science and skill could produce, were year after year undergoing alterations, suggestive of doubts as to their excellence and efficiency at any time.[2]

[1] *Appendix to the Report of the Committee of the House of Commons on Ordnance*, 1862, p. 177.

[2] In the *Committee of the House of Commons on Ordnance*, in 1863, Mr. Anderson, the assistant of Sir William Armstrong, at the Royal Factory at Woolwich, in reference to Colonel Bingham's statement, that half the field-guns in the service are patched up, says: 'To bring our 1863 knowledge and experience and standard to test the guns of 1859 would, I think, not be fair. *We do not think very much of those guns now;* the guns of 1861 were very *much better than the guns of* 1859; *the gun of* 1862 *is better than the gun of* 1861. And with my present knowledge, I think the *guns of last year are very bad in many particulars.*'—*Report*, p. 4., *Evidence*, 567.

But the duties devolving upon Sir William, so far from being limited to the care and development of his own gun, were expanded to much more important dimensions. As Engineer to the War Department, he became the *consulting officer of the crown upon artillery in general.* By the terms of his appointment, he was 'to report and advise upon all questions submitted to him by the War Department in relation to rifled ordnance; if these were referred to a committee, he was, if required, to act under the direction of that committee; but in all other cases his duties were to be exercised subject to the control of the Secretary of State for War.'[1] He was thus constituted the confidential adviser of the Government upon the discoveries of other inventors, as well as of his own—a position of the utmost delicacy and difficulty, and one in which it was hardly possible for its occupant to be regarded as an indifferent witness, or to escape the suspicion of becoming an interested umpire. It would be derogatory to the high character of Sir William Armstrong to suppose it necessary, even for form's sake, to disclaim the remotest idea of imputing to him a feeling so unworthy, much less any act ascribable to it; but to demonstrate how unwise in its conception was the creation of an office which placed its occupant, however great his reputation, in a position where his conduct was so open to misconstruction; it is only necessary to point to the fact, that other inventors abstained from submitting

[1] See *Report of the Committee of the House of Commons on Ordnance*, 1862; *Appendix*, p. 177.

their plans, through apprehension that they would fail to satisfy the Ordnance Select Committee, of which Sir William Armstrong was the constituted adviser; or else that their drawings and explanations might be made an unfair use of. Captain Blakely, during his examination by the *Committee of the House of Commons on Ordnance* in 1863, stated, that in 1860 he had been deterred by that feeling from submitting the project of a particular gun, calculated as he believed to penetrate armour-plate, which he offered to make at his own cost, and submit for trial free of expense to the Government; but which he was told would only be accepted on the condition, that 'the drawing from which the gun was to be made should be approved of by the Ordnance Select Committee.' This he declined, first, because he despaired of satisfying that Committee; secondly, because he considered 'it would be quite time enough to tell them how the gun was made if they approved' of its performance; but his principal reason for withholding the drawings was because Sir William Armstrong was the adviser of that Committee, and they might thus get into the hands of an inventor who was himself a competitor. 'I thought,' he adds, 'that thus some little alteration might be made in the gun, and that it might have been copied and represented to the country as an Armstrong gun.'[1] This suspicion, Captain Blakely says, was engendered in his mind by a previous one, by which he has since found that he did Sir William Armstrong the injustice of supposing

[1] Evidence, No. 4,756, &c., 4,774, &c., 4,782, 4,785, &c., 4,789, 4,791.

that an Armstrong gun, which he had seen at Woolwich, was imitated from one which he (Captain Blakely) had in progress there at the same time. In this he was now satisfied he was wrong; but Sir William Armstrong's official position had the effect which he avowed of deterring him from submitting his plans.[1] 'I think,' says Captain Blakely, 'that no inventor should be placed in the position of Sir William Armstrong. If I had myself been placed in that position, it would have had the same effect on other inventors that it had on me.'[2]

The appointment, as is shown by the terms in which it was made, took place at a moment when men of science, some of them eminent in their departments as mechanical engineers, were eagerly in pursuit of the best gun for national service; investigating the principles on which perfection may be attainable; and freely tendering their discoveries to the Government as demonstrative of their progress. Even after the formal adoption of the Armstrong gun as the best procurable at that period; and notwithstanding eulogies, which, however extravagant, were nevertheless the genuine outburst of surprise and admiration;[3] thoughtful men in high positions did not ignore the possibility of sooner or later discovering *a better* weapon. The Earl of Derby, as before alluded to, intimated the probability of this to General Peel in 1858,[4] who participated in the

[1] Evidence, No. 4,867, &c., 4,879, &c.

[2] *Ib.* 4,893.

[3] See *ante*, p. 146.

[4] *Report of the Committee of the House of Commons on Ordnance*, 1862, p. 112.

feeling.[1] Sir James Graham, two years later, repeated the same impression in the *Report of the Committee on Military Organisation*;[2] and during the course of the enquiry, Mr. Anderson, Sir William Armstrong's *Assistant* at Woolwich, had adverted to the practical difficulty arising out of Sir William's appointment, 'supposing Mr. Whitworth's should be found, on experiment, to be a better gun than his.'[3]

This spirit of enquiry, then active in England, it was the paramount duty of the Crown to stimulate and foster; and the passage already quoted from Sir William Armstrong's instructions, serves to show that it was in the contemplation of the Government to do so. But to confer on one highly favoured individual, however signal his ability, all the honours of early triumph, with all the material facilities of office, and the command of all the resources which office implies, was a discouragement to other rivals sufficient to paralyse energy and to stifle exertion. It was regarded as an intimation, that in the grand aim of producing a gun worthy of the national service, competition was closed, and silence imposed upon further discussion. And this was confirmed by the subsequent intimation that although as regards the nobler game pursuit was discouraged, the genius of the country might still be profitably bestowed upon 'such small deer' as the discovery or means of rifling the stores of old cast-iron ordnance, to prevent their

[1] *Report &c.* p. 112.
[2] *Ibid.* p. xviii.
[3] *Committee on Military Organisation*, 5,959, p. 424.

becoming a total loss, in consequence of the adoption of the Armstrong gun.

Besides, assuming that competition was still to go on, the position of Sir William Armstrong gave to its occupant an undue advantage in many other respects. As Superintendent of Rifled Ordnance, he was entitled to consult the official reports which detailed the performance of other guns; and to be present at trials from which not only the public but the inventors themselves were excluded. It was practically unfair to pit, against private individuals, working on their own resources, and conducting costly experiments at their own risk, a competitor thus favoured; whose experiments were conducted at the Government establishments, and their expenses defrayed from the national treasury. As a natural consequence, it is said that some of the improvements brought forward by other inventors, have been adopted by Sir William Armstrong in perfecting the Government gun—an appropriation which their authors might have resisted, had they not been reluctant to throw obstacles in the way of an official, in pursuit of what was indisputably a national object.

General Peel,[1] General St. George, and other high-minded officers,[2] do not share in this feeling, and consider that Sir William Armstrong had no greater facilities than other persons for having his ordnance tested, and that he never enjoyed any influence prejudicial to the

[1] *Committee on Ordnance,* 2,323, 2,327, &c.
[2] *Ibid.* 2,742, p. 135.

claims of other inventors. But without imputing a deliberate intention, or assigning a single fact in evidence of such a result, the very instincts of society suggest its probability. It might, in fact, be regarded as unfair to Sir William Armstrong himself, as one of the competitors in this honourable struggle, that he should be placed in a position which, instead of permitting him calmly to observe the progress of the prevailing emulation, and apply its products to the advantage of the great national establishment over which he presided, had the effect of putting him practically on the defensive; and exposed him to the suspicion of looking coldly on suggestions, however palpably for the public good, if they threatened to militate against the accepted superiority of his own productions.

But perhaps the most prejudicial consequence of Sir William Armstrong's appointment was, that it rendered the Government a *partisan* in a question in which, of all others, it was its manifest interest to be purely impartial. Having adopted the Armstrong gun as the best that was then procurable, the War Department felt constrained, in its own defence, to maintain it against all assailants, and to uphold its superiority over all possible rivals. Colonel Lefroy, when examined before the *Committee of the House of Commons on Ordnance*, in 1862, stated candidly his opinion of the practical effect of Sir William Armstrong's appointment, on the efforts of other engineers engaged in the same pursuit:—

'354. Do you conceive that Mr. Whitworth has had the same opportunity of having experiments tried, with

regard to his gun, that Sir W. Armstrong has had with regard to his?'

'No; I think not.'

'355. Why is that?'

'Because Sir William Armstrong is *the Engineer for Rifling Ordnance to the Government.* The Government has deliberately adopted his system of rifling, and *is bound to work it out.*'

'356. Sir William Armstrong is an officer in the War Department?'

'Yes. Mr. Whitworth takes place as one amongst the many competitors against him, and a very eminent one; but it is *not to be supposed that he should have the advantages that Sir William Armstrong necessarily derives from his position,* and his duties towards the Government.'

'357-8. His being a very eminent competitor with Sir William Armstrong, Sir William Armstrong's position gives him an advantage over him?'

'I think it does. . . . Sir William Armstrong being placed in that position he has necessarily both the duty and the opportunity of developing his system, which other competitors have not.' [1]

At a further stage of the same enquiry, Colonel Gardner, the chief instructor in artillery at Shoeburyness, declined to commit himself as to the merits of the Armstrong gun compared with those of any other competitor with it, on the ground that 'no gun has been tried on equal terms with the Armstrong, and therefore it is

[1] *Evidence of the Committee on Ordnance*, 1862, p. 15.

impossible at the present to arrive at any opinion. . . . No gun, he adds, has gone through the amount of experiment and trial that the Armstrong gun has, and I would not commit myself by giving an opinion on the subject.'

As opposed to Mr. Whitworth, and all other aspirants emulous of improving ordnance in general, the Government, as Colonel Lefroy says, having deliberately adopted Sir William Armstrong's system of rifling, '*was bound to carry it out,*'—bound, in self-justification, to abide by its own decision, and to resist the belief that any other system was or could be superior; and bound to cling to the Armstrong gun, incomplete as it admittedly was, rather than make way for another with better-founded claims to superiority.

Another aspect in which Sir William Armstrong's official position may be viewed is the commercial one—the influence it was likely to have upon other establishments embarked in the same branch of manufacture. It is true that the justification offered for the endowment of Elswick was the impossibility of having the Armstrong gun brought to perfection under any other auspices than those of its author; and the alleged imprudence of entrusting its manufacture to any less trustworthy contractors than those who produced it under his vigilant inspection. For an article likely to be in such extensive demand, it is no doubt a grave objection that it should be so complex or so delicate in its construction as to require extraordinary precautions for its production, involving the special organisation of a peculiar establishment. But the correctness of this latter plea,

it is right to state, has been questioned by Mr. Anderson, the chief of the Royal Gun Factories at Woolwich, who, in his evidence before the *Committee of the House of Commons on Ordnance* in 1862, stated that he did not consider this difficulty to exist in practice. Hence a question has been raised, and not unnaturally, whether any necessity existed for the creation of a new establishment at Elswick, seeing the resources which the Government were already in possession of at Woolwich, and their easy convertibility to the manufacture of the new guns and projectiles. When, therefore, Sir William Armstrong became Superintendent at Woolwich, it has not yet been shown why, with his able assistance, the existing factory there could not have been adapted, and, if necessary, extended for the production of his ordnance, with greater ease than Elswick was organised for the same purpose.

But assuming the difficulty apprehended in making the first Armstrong guns (and in the experimental stage of 1858, it no doubt existed), that difficulty could only be temporary, and in due time skilful workmen in various parts of England would have been trained, competent to undertake the manufacture; but what private speculator would be found bold enough to tender and contract in competition with the Elswick Company; which, though ostensibly private, was in reality founded by advances of capital from public sources, and enjoyed, not only the profits of success, but also a Government guarantee against the possibility of loss?

The War Department originally contemplated the probability of competition from other quarters, for a right was reserved to the Crown, in the engagement with the Elswick Company, to divide its orders with any other firm; but then the attempt to do so would have called into action the clause in the contract which awarded compensation for any loss so occasioned. Besides, what rival establishment, trading on its own resources, and responsible for its own risks, could possibly enter the market in competition with an association founded by the aid of public money, partially paid in advance for its productions, and secured against all adverse contingencies by the terms of its bond with the Crown? [1]

From such a dilemma the War Department has been relieved by the recent termination of the contract [2] with the Elswick Company. The full results were, of course, unforeseen when such a contract was entered into in 1859; nor can blame be justly imputed to those in authority by whom the arrangement was made, consulting as they did for the public advantage at a crisis of unexampled embarrassment, and acting on information apparently the most reliable that the state of the question could afford at that period.

The fallacy which pervaded the whole arrangement

[1] The agreement and explanatory documents in connection with the contract between the Government and the Elswick Company, will be found in the *Appendix to the Report of the House of Commons' Committee on Ordnance*, 1863, No, 48, p. 486, &c.

[2] The contract with the Elswick Company was terminated on the part of the Government in April 1863.

was frankly stated by General Peel, who, when examined by the *Committee on Ordnance*, in 1862, said — the gun having been accepted by the Government, 'now belongs to the Secretary of State, and not to Sir William Armstrong; nor is he to be regarded as an inventor who is at rivalry with any other person. I look upon him as appointed in order that he may *improve* as far as possible the gun which he has presented to the Government.'[1] General Peel elsewhere admits that he contemplated the possibility of a *better* gun being produced by some other competitor.[2] So long, therefore, as the Armstrong gun was only in progress, and Sir William engaged in conducting experiments to 'improve' it, he was not only still an 'inventor,' but in active competition with others eager in the same pursuit.

The influence of the same fallacy extends to Sir William's appointment as Superintendent of the manufacture both at Elswick and the Royal Arsenal. Subsequent experience has shown that the difficulty was over-estimated of reproducing the Armstrong gun unless with Sir William's personal superintendence throughout every stage of the process. His assistant, Mr. Anderson, whose appointment was simultaneous with his own, declares that from the first he conducted all the practical operations without the intervention of Sir William;[3] nor can there be a doubt that any equally able mechanical engineer would have done the same.

The shape in which the matter might originally have

[1] *Evidence*, &c., 2,323, p. 114. [2] *Ibid.* 2,312, p. 112.
[3] *Evidence of the Committee on Ordnance*, 1,333, p. 59.

been adjusted, in 1859, is that into which it has finally resolved itself, by the discontinuance of the Elswick contract in 1862, and the voluntary retirement of Sir William Armstrong, in 1863. Without being constituted consulting *Engineer for the War Department*, Sir William might, with advantage to the public service, have occupied an entirely independent position, whilst completing his experiments, accepting such encouragement and assistance as the Government could legitimately extend to him, compatibly with the just claims of every other competitor. And as regards his employment as *Superintendent of the Royal Gun-Factory*, it no longer admits of a doubt that it is not desirable, when conferring a well-merited reward upon any successful inventor, however eminent, to place him at the head of the state *manufacturing* department—a position which, as shown by the *Committee on Military Organisation*, in 1862, he could satisfactorily occupy only so long as no gun should have been discovered with qualities superior to his own. 'Should the Whitworth gun, or any other,' said Mr. Monsell in the House of Commons, 'prove to be superior to that of Sir William Armstrong, and be purchased by the Government, the *manufacture of it would have to be confided to a rival inventor!*'[1]

To the country the cost incurred by the Government connection with Elswick appears from the official evidence to have been very serious. The novelty of the manufacture rendered it difficult, at starting, to fix prices for the different articles ordered by the War

[1] *Speech in the House of Commons*, June 19, 1860.

Department, and it appears by the evidence taken by the *Select Committee of the House of Commons on Military Organisation*, in 1860, that at first, so much as 200*l.*, afterwards reduced to 170*l.*, was paid to Elswick for 12-pounder guns, which at Woolwich were made for 87*l.* 3*s.* 5*d.*, or nearly one half.[1] Colonel Boxer, one of the chiefs of the Royal Factory at Woolwich, stated in 1862, before the *Committee of the House of Commons on Ordnance*, that the amount paid to the Elswick Company for shot and shells alone, between 1859 and 1862 was 292,875*l.*, all of which could have been supplied at Woolwich without any difficulty, for 195,588*l.* (including in that sum 27,902*l.* for buildings and machinery), so that the Government would have benefitted to the extent of 97,287*l.*, besides possessing itself of a working plant as its own for continuous service.[2]

For guns during the same period, the amounts paid to Elswick are much larger, as may be inferred from the fact, that Mr. Anderson[3] stated to the same Committee, that at Woolwich he had made in three years 575 110-pounders, at an average cost of 424*l.* 13*s.* 1*d.*;

[1] *Evidence, &c.* p. 516. Sir William Armstrong, who as inspector was consulted as to this charge, says that 'in that case there was no alternative but to take the charge of the company;' and he gave it as his opinion 'that it was a fair and a proper charge. He could not see what else he could have done, but that was because the cost of manufacture at that time was so uncertain that it was impossible to define what it would be.'—*Quest.* 7,434, 7,436.

[2] *Ibid.*, p. 31.

[3] *Ibid.*, Appendix, p. 236.

whereas the Elswick Company supplied 109 of the same guns at 700*l.* each, and 50 at 650*l.*[1]

As the guarantee given by General Peel, in 1859, was only to take effect in the event of actual loss in the manufacture of guns for the Government, the gain upon these transactions will no doubt modify any claim on that score by the Elswick Ordnance Company.[2]

[1] *Evidence, &c.*, p. 189. The Elswick guns are here called 100-pounders, but in every respect they are the same as those described as 110-pounders by Mr. ANDERSON.

[2] Since this chapter was written an award has been made by which the Elswick Company have received a sum equivalent to 65,000*l.* as compensation for the cessation of Government employment.

CHAPTER V.

THE CONTEST.

MR. WHITWORTH has stated, so imperfect was the relation between him and the Committee who conducted the comparative trials between his gun and Sir William Armstrong's, that he never received from them any communication as to the result; and the adverse decision at which they arrived only came to his knowledge by accident some time afterwards.[1] This and other omissions cannot be ascribed to discourtesy, although some observations made in the course of the House of Commons' Enquiry in 1863[2] would seem to imply the possibility, that the Committee being captivated by the circumstance that Sir William Armstrong had 'proposed a gun of his construction, as well as a system of rifling of his own, whilst Mr. Whitworth's was only a brass service gun, bored on his system of rifling,' really entertained a doubt whether it was 'quite a fair way of expression *to call it his gun at all* !'[3] But

[1] *Letter to the Times*, Oct. 11, 1862.

[2] See *Evidence of the Select Committee of the House of Commons on Ordnance*, 1863, 2,420 to 2,430.

[3] See *Evidence of the Select Committee of the House of Commons*, 1863, 2,420 to 2,430. This doubt serves to recall the thesis discussed by

the members of the Committee of 1858 were fully aware that Mr. Whitworth was not a professional gun-maker, and that up to that time he had been a disinterested adviser of the Government; giving the aid of his scientific attainments and mechanical experience for the improvement of an important element in the public service,—and this not only without any desire of reward, but, as stated by the Special Committee who had just investigated the expenditure incurred, at the actual 'loss of interest on money advanced by him; whilst the country had the benefit of the services of the first mechanician of the day, energetically endeavouring, by means of an experienced staff and beautiful machinery, to solve the problem of the true principle of rifling.'[1]

The patents of which Mr. Whitworth possessed himself were, of course, of high value; and it is due to him to state that, whilst he handed over unconditionally to the Crown the right to use those for the rifled musket, the actual cost of his experiments with which were refunded from the public treasury, (but inclusive of no remuneration for his personal services,) he continued, long after the severance of his more intimate relation with the War Office, to place at the disposal of the authorities the use of his patents for further discoveries, the expenses of which were defrayed from his private

theological casuists in the middle ages, whether scrupulously as well as anatomically considered, *a father could properly be said to be any relation to his own child!*

[1] See Report, *Appendix to the Evidence of the House of Commons' Committee on Ordnance*, 1863, p. 525.

resources; thus enabling them to be turned to advantage in the furtherance of a great public object, as was the case in the instances of the lubricating wad, and the flat-fronted projectile for penetrating armour-plate.[1]

Judging from such expressions as have been uttered in public by Mr. Whitworth, his feeling, on being made acquainted with the adverse decision of the Committee, was not so much that of disappointment that his own gun had not been chosen, as of regret that it *had not been sufficiently tried.* Captain Noble, a member of the Committee by whom the Armstrong gun was recommended for adoption, stated to a Select Committee of the House of Commons five years after, that before coming to that decision 'Mr. Whitworth's gun was tried altogether about eight or nine times, and Sir William Armstrong's from forty-five to fifty times.'[2] It has already been observed, that the instructions of the Committee were to proceed 'as speedily as possible'; but even consistently with that injunction, so very hurried an enquiry was obviously as insufficient to determine the superiority of one gun, as it was inadequate to test the positive merits of either. The important merits of wear and tear, and endurance, demanded a more prolonged investigation, irrespective of the detailed comparison of two totally different systems of loading and rifling, and of two varieties of projectile, not only distinct in their

[1] *Report of the British Association*, 1861, p. 354.

[2] *Evidence, &c.*, 3,080, 3,082, 3,105, &c. The Duke of Cambridge on the same occasion gave it as His Royal Highness's opinion, that the Whitworth gun had not, up to that time, been as thoroughly tried as Sir W. Armstrong's. *Ibid*, 1,239.

configuration, but in the metals of which they were respectively formed. The unsatisfactory issue of the late enquiry was thus summed up by Sir Howard Douglas:—'The comparative value and importance of the Armstrong and Whitworth guns (so essentially different in construction, dimensions, faculties, and aptitude that they cannot be *equally* adapted to all the requirements of general service) can only be correctly estimated, fairly judged so far as they satisfy the principles of gunnery, and their real service uses proved by actual experiment and protracted trials under circumstances resembling as nearly as possible the requirements and vicissitudes of war.' [1]

Still, it does not appear that this repulse, vexatious as it undoubtedly was, would have led to an interruption of the good offices which Mr. Whitworth was then gratuitously rendering to the public, had not another untoward event precipitated their sudden suspension. Experience had not yet demonstrated the unsuitability of cast iron, as a material for the construction of rifled cannon; and towards the close of 1857, Lord Panmure, then Secretary of State for War, encouraged by the complete success of Mr. Whitworth in rifling the brass-guns which had been entrusted to him, directed a cast-iron block for a 32-pounder to be forwarded to Manchester, to undergo the same process; the intention being to determine the capacity of that metal for the manufacture of rifled ordnance. This gun burst under trial; as did another of the same metal and calibre, which in

[1] *Naval Gunnery*, Part II. chap. v. p. 221.

the following summer was likewise supplied by the Government. But notwithstanding these evidences of the insufficiency of cast iron, Mr. Whitworth rifled a third gun, a 68-pounder, in June 1858; the more immediate object being to test the power of a projectile, newly invented by himself, in the confident hope of being able by its assistance to penetrate wrought-iron plates. The particulars of this important experiment, and the gratifying issue of the attempt, will be mentioned in another chapter;[1] but the triumph of the new projectile was the destruction of the gun, which was rent into fragments by the explosion,—thus definitely settling the question of the insufficiency of cast-metal for such services.

In reply to a letter from Mr. Whitworth, explaining the causes of the accident, and deprecating the further use of cast metal for rifled cannon, the Secretary of State directed him to be informed of his determination 'to discontinue further experiments with ordnance *rifled on his principle*.'[2]

There was something to be regretted in the time, as well as in the terms, of this peremptory order. Its import was unusually grave, inasmuch as it embodied a condemnation issuing from the highest constituted authority in such matters, not merely of an individual misadventure, but of the whole *system* under which Mr. Whitworth's operations were carried on. It was a

[1] See *post*, Part III. chap. iii. p. 254.

[2] Letter from the War Office to Mr. WHITWORTH, Dec. 20, 1858. See *Evidence of the House of Commons' Committee on Ordnance*, 1863, p. 109.

solemn repudiation, as applied to ordnance, of the very 'principle' which but a few months before had been crowned with such signal success in the case of rifled small arms.

But in addition to this, the sudden resolution to get rid altogether of Mr. Whitworth and his experiments followed fast upon the *Report of the Ordnance Committee* in favour of the Armstrong gun; and its announcement was concurrent with the negociation for securing the services of Sir William Armstrong, as Director of Rifled Ordnance, and Engineer to the War Department.

Thus the man who but a short time before had been confided in by the Commander-in-chief of the British army as the 'most celebrated mechanician of his country,'[1] found himself suddenly assailed on the tenderest point, his professional fair fame; and for the vindication of this, he on the instant from an amateur artillerist became a professional gun-maker. 'He had not had previously,' as he stated to the House of Commons' Committee of 1863, 'the most distant idea of becoming a manufacturer of rifled arms.[2] I took it up,' he said, 'originally, solely because I was requested by the Government, but when I received this letter from General Peel to inform me that no more experiments were to be made with guns on my principle, I determined at once to become a manufacturer

[1] See *ante*, Part I. chap. ii. p. 22.

[2] 'Mr. WHITWORTH's object was to ascertain what is the most perfect form of a rifle that can be produced, and then to *leave it to others to make and use it.*'—*Edinburgh Review*, 1859, p. 524.

and to prove that my system was right. With respect to the rifle, it has already been shown that it was so; and I think it will soon be admitted, that I was right with regard to ordnance also.' [1]

'It does not follow,' says a high ethical authority, 'that a man is the discoverer of any art merely because he is the first to say the thing, but he who says it so long, and so loud, and so clearly, as to compel mankind to hear him. It is the man who is so deeply impressed with the importance of his discovery that he will take no denial; but at the risk of fortune and fame, pushes through all opposition, determined that what he feels he has discovered, shall not perish for want of a fair trial.' [2] Such was the instinct which impelled Mr. Whitworth to become the producer as well as the inventor of his own gun; and under the influence of that feeling, he at once founded a rifled ordnance factory at Manchester.

In the new career into which he found himself thus unexpectedly forced, his object was, not as in the instance of Sir William Armstrong's appointment to Woolwich, '*the maturing and perfecting of his system of rifled ordnance*,' his system of rifling being already as perfect as it was in his power to render it; but to obtain for it, by an appeal to public opinion, a dispassionate trial, an ample investigation, and a deliberate judgment.

In pursuit of this, the grand obstacles which he had

[1] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1863, 1,438.

[2] The Rev. SYDNEY SMITH.—*Edinburgh Review*, 1826.

to encounter were the dominion of routine, and the influence of *esprit de corps* on the service, which sometimes acts like a superstition of caste in resisting all improvements from without. Monasticism, with its unsympathising self-reliance, is not confined to religious houses and ecclesiastics. Its influence is susceptible of equal development in fraternities of laymen. It is the natural growth of sectional training and professional segregation. It is as discernible in the college as in the convent; and the retirement of the Inns of Court or the counting-house is not less likely than the seclusion of the cloister, to engender contracted habits of thought and confirm isolated motives of action. The same shrinking from identification with the world without, which animates the asceticism of a monastery, may be traced to a kindred source in the discipline that inspires the self-esteem and exclusiveness of an orderly room and a barrack. Lord Elcho stated in the House of Commons, in 1861, that from the first, when Mr. Whitworth was called in by Lord Hardinge to advise as to 'the best principles on which rifles should be made, there arose a feeling of prejudice against him *because he was an outsider*.'[1] And yet, by a strange anomaly, an 'outsider,' if once formally admitted into the service of the War Department, appears to be received with all the warmth, and defended with all the energy, which characterise the military fraternity. The reason is, that the stranger has entered under the auspices of authority; and *authority* is that mysterious principle

[1] Lord Elcho's *Speech in the House of Commons*, June 25, 1861.

which commands, and *properly commands*, the unfaltering worship of an army, in the organisation of which it is as essential as it is puissant.

Amongst themselves, and in relation to affairs exclusively military, this system has its advantages. Men become partial to habits of action which are peculiar to their own class; and the inculcated belief, that whatever is done by authority must be right, not only reconciles those whom it concerns to its inconveniences, but disposes them instinctively to defend it against all uninitiated assailants.

But not so as regards the public. This regimental discipline cannot safely be extended to them,—and in the relation of the army to civil affairs, discussions arise and interests become involved, that cannot be disposed of by the same forms and processes which may work satisfactorily under a martial code. Military trials are generally called for by sudden emergencies, and those familiar with such tribunals are prepared to be satisfied with vigorous action and prompt conclusions. But scientific investigations cannot be properly conducted with the summary rapidity of a court-martial. In the Select Committee which tried the Armstrong and Whitworth guns in 1858, the members were exclusively naval and military officers, whilst the parties on whose interests they were to give judgment were as exclusively civilians. Hence the issue of the trial excited much discontent amongst classes unaccustomed to the military aspect of the proceedings; and whilst no man in England thought for a moment of imputing

partiality to the judges, confidence in their judgment was impaired by the insufficiency of their experiments.

The redress of this error was the object now aimed at by Mr. Whitworth; but in its pursuit he had to encounter prolonged discouragement, from the reluctance of those in office to reopen a great question which had been so recently closed; from the impulse of the majority of military officers to uphold the acts of the Ordnance Committee, and from the difficulty of obtaining reports and other official documents for the ultimate establishment of right. Under such sinister auspices, and retarded by difficulties incident to the novelty of the situation, the effort was at first tedious and dispiriting. The main cause of this was the fact that Mr. Whitworth at the moment had no guns of his own making; and was obliged to defer a public appeal till he should first provide these.

In the mean time, Sir William Armstrong, with all the éclat of brilliant success, and sustained by the elevation of office and the almost boundless resources of his new position, was enabled to display to the utmost advantage the surprising power of the exquisite piece of mechanism he had produced. The army, with a very few exceptions, were delighted with the acquisition of their new field-pieces; although the complexity of the parts involved the necessity of an entirely *new drill* for the artillery, an inconvenience which would not have been incident to the simpler form of the Whitworth gun.[1] And the nation in general, always prone, as

[1] *Report of the House of Commons' Select Committee on Ordnance*, 1863, p. v.

the *Times* pointed out at the moment, to think that each fresh invention in mechanics is to be the *last* of its kind, was so charmed with the beautiful cannon, so far transcending the old ordnance, as to believe it the *ne plus ultra* of artillery, and to look on further improvement as impossible.[1]

But whilst the multitude were thus captivated by the attractive mechanism and elaborate workmanship of the Armstrong gun, by the novelty of loading at the breech instead of the muzzle, by the combination of two metals in the strangely shaped projectile, by the bold idea of spontaneous rifling, and the ingenious device (since abandoned in field-pieces) for counteracting recoil; as well as by its other peculiarities,—the reflecting section of the profession and the service had their attention still fixed on the familiar bronze cannon, bored and rifled on the Whitworth plan, which recommended itself to confidence by its strength, its simplicity, its surprising powers, and sturdy endurance. Apprehension began to be entertained whether, in an unguarded moment, the Government, like the princess in the story of Aladdin, had not listened to the cry of the magician, and hurriedly exchanged the old lamp for a prettier new one.

The press became gradually divided in the controversy, but the periodical organs of scientific bodies were unanimous in apprehending precipitancy and enjoining caution. The most distinguished mechanicians were prudently silent, and disposed to suspend the expression of opinion in a case in which few were sufficiently

[1] *The Times*, Feb. 17, 1860.

conversant with the facts; since science in its exact forms can hardly be said to have been applied to the construction of rifled fire-arms before the experiments of Mr. Whitworth. The body of civil engineers threw open the theatre of their Institute, and invited unembarrassed discussion upon the all-engrossing topic of the *Construction of Artillery*[1] and members of the British Association for the Promotion of Science availed themselves of its meetings, to advance opinions suggestive of the necessity of further experience before coming to a conclusion on data still incomplete.

Thus the decision of the Ordnance Committee, which, under other conditions, ought to have inspired universal confidence, and put an end to competition, served only as a signal for the commencement of a far more vigorous contest, amidst the din of which Mr. Whitworth proceeded to arrange his machinery for the production of a piece of ordnance, the future performance of which was to vindicate its own title to the qualities he claimed for it.

In the principle of *rifling* which he had elaborated he had no improvements to introduce, in regard either to range or precision; but fully aware of the prodigious force which he was enabled to wield, his only difficulty was to provide himself with a metal of such strength and endurance, as to curb and control the stupendous power of gunpowder. It was the old-

[1] The report of the discussion which arose in consequence has been recorded in the *Proceedings of the Institution of Civil Engineers for* 1859-60, as well as reprinted in a separate volume by their authority.

world story of the Syracusan philosopher conscious of the irresistible might of his lever; but in search of a *fulcrum* from which to move the Universe.[1]

Whilst the application of *rifling* to artillery had disclosed the prospect of hereafter employing the enormous power of gunpowder to an extent previously unforeseen, the early progress made had already served to reveal the fact that no one of the metals heretofore used for the making of cannon of an ordinary size was any longer equal to resist its tremendous and immeasurable rending force, when exerted on a grand scale and in guns of great calibre.[2] It must likewise be borne in

[1] The exclamation of ARCHIMEDES: δὸς ποῦ στῶ καὶ τὸν κόσμον κινήσω!

[2] Mr. LONGRIDGE, in a paper read before the Institution of Civil Engineers in 1860, quoted the authority of ROBINS, who calculated the ultimate strength of gunpowder to be 7 tons on the square inch, equal to the pressure of *a thousand atmospheres*; and of HUTTON, who believed it to be 17 tons, or 2,400 atmospheres. Colonel BOXER, in his *Treatise on Artillery*, makes it 14·4 tons per square inch. Mr. LONGRIDGE himself estimated it at 20 tons; but other authorities, he adds, assumed that this might be doubled. A well-informed writer in the *London Observer*, Nov. 15, 1863, says the strength of gunpowder in a state of explosion is so vast, and it is from its very nature so difficult to test, that it need not be a cause of surprise that those who have devoted the greatest amount of time and attention to the subject are still at a loss to estimate it with anything like certainty. The imprisoned forces which lie within the ingredients of this substance are such that, when set free, they occupy a space 317 times greater than when in the grains of powder. One cubic inch of gunpowder will evolve on explosion 79·4 cubic feet of nitrogen, and 238 of carbonic acid. The whole of this increase of bulk takes place instantaneously; the gases are liberated by a spark, with a rapidity greater than the speed of lightning. But this calculation of the quantity of gases set free at the moment of explosion is given only according to the space which they would occupy *at the ordinary temperature of the atmosphere*. Within the barrel of a gun the *heat* at the moment of explosion has been calculated at 3,000 degrees,

mind, that gunpowder itself may not even yet have attained its highest development, and that its powers may sooner or later be increased by some new apportionment of its parts. For certain objects it may even be superseded by gun-cotton or some equally explosive agent, so that a metal with the fabulous endowments of adamant, may ere long become no merely speculative or conjectural requirement.

Meanwhile, as already stated,[1] before Mr. Whitworth commenced to work on his own account, almost every known material for the manufacture of guns had become distrusted and obsolete. The utter failure of *cast iron* had been the immediate cause of the rupture between the Government and himself. Sir William

and this causes such an expansion of the gases, that they *would fill 2,154 times the space which the powder originally occupied.* The force of the pressure exerted by these gases has been estimated at from 14 to 80 tons upon each square inch. The mind fails to comprehend the tremendous pressure which must be exerted in the chamber of one of the large guns intended to operate against the iron plates. This enormous force is generated instantaneously, not gradually as in the case of steam, and it acts upon the metal of the gun with a tremendous blow. In the case of an 80 lb. shot, a velocity of 800 feet in a second is communicated in the three-hundredth part of a second; and in the case of a rifle bullet, the same velocity is acquired in the three-thousandth part of a second. In the case of steam, its power is so well understood that it enables one to form some comparison with that of gunpowder. A small 3-pounder shot ejected from a gun at a velocity of 1,300 feet per second, and with a force generated in the two-hundredth part of a second, requires a power equal in its mechanical effect to that necessary to raise 1 lb. to 78,000 feet. One nominal horse-power is uniformly represented by 33,000 lbs. raised one foot high per minute, or $2\frac{3}{4}$ lbs. in the two-hundredth part of a second. *The work performed by the eight ounces of powder used as a charge in a small 3-pounder gun is equal, therefore, to 28,000 horse-power.*

[1] Part II. chap. i. p. 85, &c.

Armstrong had tried and been equally unsuccessful in hooping and rifling cast-iron guns.[1] *Brass*, with all its fine qualities, discloses infirmities which even for field guns rendered its power of endurance doubtful; besides, its cost and weight interposed an obstacle to its introduction on any vast scale for the production of large ordnance. The imperfections incident to *wrought iron* in a solid form precluded its use, except as applied by Sir William Armstrong. But welded coil had not then, nor has it yet, manifested exemption from the common risk, when used with large charges in rifled guns of great calibre. Forced to resort to a substitute, Mr. Whitworth adopted the material to which he has given the name of 'homogeneous iron,' and which with the toughness and ductility of that metal combines the hardness and tenacity of steel. In its preparation, bars of the finest charcoal iron are cut into short lengths and melted in crucibles; the contents of which, after being collected and cast into ingots, are forged by steam-hammers of prodigious power and weight. The preparation of metal by this process has been successfully carried on in England; but the greatest establishment for its production in Europe is that of M. Krupp, at Essen, in Rhenish Prussia. There the larger masses are forged by an enormous hammer, the head of which, its piston and rod, weighs 50 tons; and this with

[1] See *Evidence of the House of Commons' Committee on Ordnance*, 1863, 3,228, as to the tendency of brass to 'crush and draw out in length' when guns are fired with large charges.

a fall of ten feet, accelerated by steam acting above, strikes a blow equal to 2,000 tons weight.[1]

The tenacity of metal forged under such conditions is attested by the fact that a bar of Krupp's iron one inch square has borne a weight of 50 tons, when one of common wrought iron broke under the strain of 33 tons. Dr. Abel, the head of the chemical department of the Royal Factory at Woolwich, has stated that a gun of this metal cast at Essen had been tested in this country, and that 'it was found almost impossible to burst it.'[2] This inference was sustained by a statement of Mr. Whitworth, made to the Institute of Civil Engineers in 1860,[3] in relation to his own experiments with homogeneous iron, when used for small arms and muskets. 'He had put into a rifle-barrel, 1 inch in diameter at the breech, with a bore of ·49 inch, a leaden plug 18 inches long, as tightly as it could be driven home; it was fired with an ordinary charge of powder, and the long leaden plug being expanded by the explosion remained in the barrel, the *gases generated by the gunpowder all passing out through the touch-hole,* which was small and lined with platina. The lead was then melted out of the barrel, and the same experiment repeated four times, with the same results.'[4]

[1] This process of forging has of late been facilitated, in Sheffield, by casting the metal into cylinders, which are hammered on a mandril; the force of the blow being intensified by reducing the thickness of the object struck.

[2] M. Krupp, I understand, is at present constructing a steam-hammer of 100 tons for this manufacture.

[3] *Proceedings of the Institution of Civil Engineers,* 1860, p. 85.

[4] *Ibid.* p. 110.

So far as concerns the soldier's musket, Mr. Whitworth was therefore satisfied that the homogeneous metal was sufficiently strong to resist the greatest strain to which in practice it could ever be subjected; but whatever might be its sufficiency for small arms and field-pieces, its suitability for artillery and heavy ordnance was still open to question. Mr. Anderson, the Assistant Engineer at Woolwich, expressed doubts of its durability, and looked upon it 'as most uncertain in character, one gun standing well, whilst another burst without warning, the same care being bestowed on each by the founder.'[1] Sir William Armstrong shared the same distrust of iron forged in large masses;[2] and Mr. Whitworth, after numerous trials of the new material, gave it as the result that 'in employing homogeneous iron for rifled guns, experience alone can determine the proper temper. It must be hard enough,' he said, 'to resist wear, the action of the gases of explosion, but not so hard as to cause the metal to crack instead of bulging, when acted upon by a pressure greater than it is calculated to bear.'[3] Thus, cautiously treated, and with becoming care, he was hopeful that large ordnance, as well as smaller guns for field service, might be made of homogeneous iron, without the precaution of encasing the former with hoops of the same material.[4]

Down to the present time, however, this sanguine

[1] *Proceedings of the Institution of Civil Engineers*, 1860, p. 69.

[2] *Ibid.* Discussion *on National Defences*, 1860–61, p. 83, and *Address to the Society of Mechanical Engineers*, at Sheffield, 1861.

[3] *Letter to the Times*, October 31, 1861.

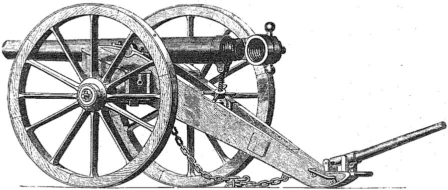
[4] *Proceedings of the Institution of Civil Engineers*, 1860, p. 111.

anticipation has not been fully realised. Light field-pieces, and even 12-pounders, have been successfully and securely made by boring and rifling solid blocks; but for guns of a large calibre, the necessity has not yet been dispensed with of strengthening the barrel by surrounding it with concentric hoops of the same metal. Nor have the latter in every instance withstood the force of explosion; and although accidental causes have been assigned in individual instances to account for such mishaps, the liability to their recurrence is demonstrative of the fact that the art of the metallurgist has not hitherto kept pace with the advancing necessities of the gun-maker; and that a metal of inexpugnable tenacity is still the grand desideratum of the military engineer.[1]

Nor are the evidences of this peculiar to any one description of metal, or confined to the productions of any particular aspirant in gunnery: for the terrace on the Thames, between the margin of the river and the façade of the Royal Factory at Woolwich—which by a stroke of grim humour has acquired the name of the '*cemetery*'—is thickly strewn with the carcases of bursted cannon, of every known species of iron, and of almost every attempted construction, torn into fantastic fragments by the untameable fury of gunpowder.

In the process adopted by Mr. Whitworth for making heavy ordnance, the inner tube is formed out of one piece of homogeneous iron, and its external diameter

[1] See the evidence of Sir William Armstrong on the question of steel and metal for guns in general. *Evidence of the House of Commons' Committee on Ordnance*, 1863, p.134.

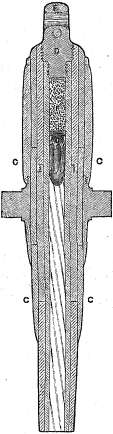


THE WHITWORTH MUZZLE AND BREECH-LOADING RIFLED GUN.

tapers about an inch in every 100 inches of its length. Over this, the hoops, also of homogeneous metal, and each from twenty to forty inches long—their interior surface being fitted with mathematical accuracy to the exterior surface of the tube—are forced slowly on by hydraulic pressure till the requisite amount of tension, which is easily calculated, is arrived at. Thus, heating the metal for welding hoops, or for 'shrinking' them on, as practised at Woolwich, is altogether dispensed with in the construction of the Whitworth gun. A second series of hoops is in like manner drawn over the first, and in the largest cannon a third, or even a fourth, is super-imposed by the same process. The accompanying *section* of a muzzle-loading gun, calculated to fire a projectile of 70 lbs., exhibits the arrangement of the hoops, and the relative positions of the projectile, wad, and charge.

The *rifling* of the cannon in Mr. Whitworth's factory of course presented no new feature; it was the same which had been uniformly applied, since experience had determined the principle, and shown its applicability to fire-arms of every size and description.

One peculiarity, however, of his system as applied to artillery, consisted in the diameter of the bore being *uniform throughout the entire length of the barrel,* without leaving any 'chamber' or recess to contain the charge of powder, at the end next the breech. In this it differed from the Armstrong gun, in which, as the projectile was to be rifled by compression during its passage through the grooves in the barrel, it was in-



WHITWORTH MUZZLE-LOADING 70-POUNDER.

A A The internal tube rifled hexagonally.
B B The first series of hoops forced on by hydraulic pressure.
C C C C Additional hoops placed on exteriorly to the above.
D The breech, with the aperture at E to admit the friction fuse.
F The charge.
G The rifled projectile.

dispensable to have the aperture wider at the breech, where the projectile was to enter, than at the muzzle of the gun, whence it was to issue after being forced through the whirls of the rifling. The manifest advantages of Mr. Whitworth's arrangement were, not only that the gun was a muzzle-loader, as well as a breech-loader, but that it also possessed the faculty of permitting the weight of the projectile to be increased by increasing its length to any extent compatible with the power of the piece to resist the increased strain. In fact, from the same gun he fired a spherical ball of a diameter equal to *one* calibre, and one whose length was equal to *ten* calibres; as well as others of intermediate gradations.[1] Besides solid shot, the guns were calculated to fire shell of every variety, even those filled with molten iron.

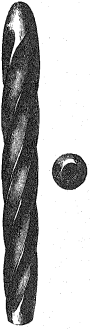
The credit of determining the superiority of an elongated to a spherical projectile, belongs to a period much earlier than our own; but Mr. Whitworth is entitled to the merit not only of demonstrating that projectiles of any requisite length might be fired without the risk of 'turning over' during their flight, by increasing the velocity of their rotation in a like proportion;[2] but that greater precision could be imparted to them by accurately shaping the shot so as to cause it to centre itself within the polygonal rifling of the gun.

For field-pieces and heavy guns he made the projec-

[1] See illustration p. 184.

[2] See *ante*, Part I. ch. iii. p. 39.

tiles of iron, fitting them to the bore, by means of self-acting machinery, at so trivial a cost, that the expenses for wages did not exceed 1*d.* for each shot of twelve pounds;[1] and for certain services they may be merely cast, the hexagonal shape being given by the mould.



EXPERIMENTAL PROJECTILES FIRED FROM THE SAME WHITWORTH GUN.

To shot of this description exception has been taken by Sir William Armstrong and others, that the wear of the gun would be precipitated by the friction between its surface and that of the hard metal projectile, and also that the unyielding nature of the latter would involve the danger of 'jamming,' and the consequent destruction of the piece. Mr. Whitworth has met these objections by the fact that in practice the latter accident has not occurred; and that experience has shown that after long continuous firing even with brass guns, the proper wads being used, no appreciable wear and tear was caused by the iron projectile. Without limiting observation to projectiles and guns, the familiar instance of the piston and cylinder of a steam-engine, or the bearings of a revolving crank, are sufficiently illustrative of the

[1] *Proceedings of the Institution of Civil Engineers*, 1859–60, p. 108. Charges still lower were named by Mr. WHITWORTH before the Committee of the House of Commons in 1863. See *Evidence*, 2497, &c. p. 108.

fact, that with proper lubrication the contact of the hardest metals may be attended by no serious injury from friction.[1] One of the earliest Whitworth guns, after firing 1,500 shots, showed no more sign of abrasion than when it first left the workman's hands. Besides, the damage, if any, from friction must be *mutual*, it must be equally exhibited on the projectile as well as on the gun; but so far from this being apparent, projectiles fired from the Whitworth guns are constantly picked up in a condition so perfect as to be capable of being fired over again. Whatever weight there may be in the apprehension of excessive friction, it remains as yet unattested; and the House of Commons' Committee on Ordnance in 1863, have stated in their *Report* that

[1] *Evidence of the Committee of the House of Commons on Ordnance*, 1863, 3165, 3925, 3949. Capt. HEWLETT (*Evidence*, 3309, &c.) was of the same opinion, but his experience of the Whitworth gun had been confined to the cast-iron 80-pounder which burst on board the 'Excellent' in 1859. See Part III. chap. iii. p. 254.

On the subject of friction Mr. WHITWORTH stated as follows to the Committee of the House of Commons in 1863:—'The wear in my guns is comparatively very small. There is wear in all guns, arising from the effects of the explosion of the powder, but owing to the great extent of the surfaces of the projectiles in contact with the bore of the gun, the wear due to friction is reduced in my guns to a minimum' (2466). In the course of the enquiry by the House of Commons' Committee in 1863, it was stated that a battery of brass guns, 12-pounders, supplied to the Government by Mr. WHITWORTH in 1862, had suffered from friction by the projectile: to which Mr. WHITWORTH added the expression of his surprise that they had not suffered much more than they did; inasmuch as, from some unexplained oversight, they had actually been *fired without wads*, 'without one particle of lubrication, and without one drop of water being used for 100 rounds. Such a thing was never known or dreamed, that surfaces sliding upon one another should be used without lubrication.' *Evidence of the House of Commons' Committee*, 1863: 2572, 3018, &c.

'no sufficient experiments have been tried' with the Whitworth gun to show whether his projectiles are liable to this objection.[1]

There is one peculiarity in the external shape of the Whitworth elongated projectile, the effects of which are suggestive of curious conjecture. The original form adopted by him for the rifled musket was a cylinder, the anterior section being terminated by a somewhat conical front; the sides being carried on parallel to the extreme end.[2] With it during his first trials in 1857, he obtained the extreme ranges already alluded to. But the rifling lines acting like rudders, gave a bias to the bolt during its flight; a defect which was corrected by making it *taper* towards the rear. This produced a remarkable improvement in the range, imparting both flatness of trajectory and precision of flight. This result had been anticipated, as it was inferred that the rear of the shot, being tapered like the run of a ship, the air displaced in front during the flight of the projectile, and which in the case of a powerful cylinder would press on the sides and retard it, would, the end being tapered, close in rapidly in the rear, and force it forward; as the closing in of the water adds to the onward motion of the vessel.[3]

The effect was extraordinary; the range being increased from 2,000 yards, with the paralled projectile, to

[1] *Reports* &c. p. viii.

[2] See Part I. chap. iii. p. 38.

[3] See a Paper by Mr. Aston on the *Report of the British Association*, 1861. Transactions of Sections, p. 254. *Evidence, House of Commons' Committee*, 1863: 258.

2,500 with the tapered one, the proportion increasing at longer ranges. The correction of the lateral deviation was equally important; and, in short, this change by reducing retardation became equivalent to an increase of propelling force.

CYLINDRICAL WHITWORTH PROJECTILE.

TAPERED WHITWORTH PROJECTILE.

In the original shape, a rifled cylindrical projectile with the sides parallel throughout their entire extent was capable of being driven 5,000 yards, or nearly *three miles*, but by this apparently simple alteration in the rear it was sent 7,000 yards, or nearly one mile farther, although the charge of powder and the elevation of the gun were alike in each instance.

This tapering form is also favourable to the lubrication of the gun by the use of the wad before described,[1] and is equally compatible with any amount of windage, thus rendering it as well adapted for muzzle-loading as for breech-loading guns. As all guns whatsoever, when repeatedly fired, become more or less 'fouled'

[1] See *ante*, Part I. chap. iii. p. 55.

by the residuum of the exploded powder, 'easy loading' by the muzzle must be provided for by allowing the necessary 'windage' in the gun. That is to say, the projectile as it enters must fit it so loosely as not to be stopped by any accumulated deposits on the barrel, or even by imprisoned air, which would prevent it being 'rammed home.' To provide for such contingencies, the expedient resorted to by Mr. Whitworth was to remove that portion from each half side of the hexagonal bore of the gun on which the right half side of the projectile bears *as it goes in*, thus enabling it to enter with what is in fact a 'loose fit,' but as in *leaving* the gun, the shot bears upon the opposite half sides of the hexagonal bore which have not been eased off, the fit becomes close, and the projectile issues with its axis in line with that of the piece.[1]

As regards the firing of shells, Sir William Armstrong at one time doubted the desirability of throwing shells as well as solid shot from one and the same gun, and thought it preferable to have separate guns; but this was before he had succeeded in making his admirable segment shell, already alluded to.[2] Mr. Whitworth from

[1] In addition to his other projectiles Mr. Whitworth used a tubular one for penetrating wood and other soft substances, by which a core, or cylinder, nearly 2 feet long, and 1½ inch in diameter, has been cut out of a solid oak block, through which it was fired from a 24-pounder rifled brass howitzer. The tubular form was also found to be the best for penetrating masonry.

[2] See *ante*, Part II. chap. ii. p. 114. In the *Report on Rifled Guns*, furnished to the War Office, July 14, 1855, Sir William Armstrong says of his own gun, as it was at that time constructed: 'It may, perhaps, be objected to this gun, that, from the smallness of the bore, it

the first appears to have been confident that the same kind of projectiles, solid or hollow, which are used for smooth-bore cannon, were capable of being used in rifled ordnance, although fears were expressed by others that the rapid pitch of the rifling would be liable to bruise a shell, and tear it to pieces in the barrel.[1] The earliest attempt was sufficient to dissipate this apprehension; amongst the very first experiments hexagonal shells were fired with the same security as hexagonal shot; and with the farther advantage, over a spherical shell, and also over the Armstrong shell, that the hexagonal cylinder admits of being made of various lengths and capacities, for various distances and requirements, and each adapted to the calibre of one and the same gun, which they do not.

Breech loading has been a seductive problem for gun-makers at almost every period subsequent to the discovery of gunpowder, and the inventive mind of Mr. Whitworth was too susceptible to be indifferent to its allurements. But it did not require a very long experience to lead him to the conviction that there is no advantage attainable by breech loading to compensate for the inevitable loss of simplicity and strength. The public, however, were at the moment so captivated by this feature in the Armstrong gun, that it had become

cannot be applied for throwing shells as well as solid projectiles; but the fact is, these two purposes are incompatible with each other unless both be imperfectly attained, for while the one necessarily requires a large bore, the other demands a small one; and it therefore seems preferable to have separate guns especially adapted for each application.' See *Appendix to Report of Ordnance Committee*, 1862, p. 162.

[1] *The Naval and Military Gazette*, Saturday, Feb. 24, 1860.

almost compulsory upon any competitor to display a like attraction;[1] besides which Mr. Whitworth had the conviction that, mechanically regarded, the breech-loading apparatus of Sir William Armstrong was faulty, and that the object was attainable by a safer device. In his judgment a breech-loader should be rifled on a principle which, like the polygon, would admit, in cases of need, of the gun being used as a muzzle-loader also.

The arrangement which he applied to his own gun was the least complex imaginable; the breech was screwed to the barrel like that of any ordinary fowling-piece, with the difference that it is screwed *on* to instead of *into* it. In form it is a cap, with an internal screw fitted to an external one on the rear of the gun, and turned on and off by a handle. The screws are double threaded, so that the work is done by two and a half or three turns. The cap when off the breech is supported by a hoop which being provided with a hinge-joint can be swung to one side to admit the insertion of the charge. The accompanying illustration[2] serves to exhibit the system, in which it will be observed that there is nothing to weaken that which ought to be the

[1] 'In 1856 I advocated, as I still do, the employment of the simple muzzle-loaders for field artillery. . . *But at that time the breech-loader was considered to be a great desideratum;* and the practicability of firing hard metal projectiles in contact with a metal bore was so much doubted, that the lead-coated shot of Sir WILLIAM ARMSTRONG was preferred, notwithstanding the complication of its construction and its much greater cost.'—Mr. WHITWORTH, *Letter to the Times,* October 29, 1861. See also *Evidence of the House of Commons' Committee on Ordnance,* 1863, p. 107.

[2] See engraving to face p. 181.

strongest part of the gun, the breech. There is no reduction of its solidity, no slot, no vent-piece, and no movable appendage, liable to be injured or lost.

In loading these guns from the muzzle there is no departure from the ordinary custom. In loading at the breech, a few backward turns of the handle unscrew the cap, which, being received and supported by the hoop, is swung back and to one side, leaving the aperture of the barrel open. Into this the projectile is pushed, and behind it is inserted the lubricating wad and the powder, enclosed in a tin cartridge case, hexagonally shaped, to adapt it to the bore. This, as it enters, pushes forward the projectile. The powder is retained in the cartridge by means of the *wad*, composed of a mixture of tallow and wax, and in the rear of the case is an orifice to correspond with the *vent*, which passes through the centre of the breech cap.

The projectile and charge being duly lodged, the hinged hoop is swung round like a door, and a few forward turns of the screw fixes it firmly in its place. An ordinary *friction fuse* is then introduced into the vent, the operation of sighting being carried on simultaneously; and the fuse being then ignited by the jerk of the lanyard, the gun is discharged. The metallic cartridge assists in preventing the escape of gas from the breech; and when the cap is again opened, the tin case is withdrawn by an ingenious instrument which grips and extracts it, bringing away with it all deposits, which would otherwise have fouled the barrel, the entire length of which is so effectually lubricated by the

wad as to obviate the necessity for sponging or washing out the piece.

The gun being rifled uniformly from muzzle to breech, and there being no powder chamber, it is equally available as a muzzle-loader or as a breech-loader; and in the former case all that is required is to screw home the breech cap, placing in front of it a disc of copper, the expansion of which renders the joint impervious to the gas of explosion. Such is the strength of the parts in this apparatus, and such the simplicity of their adaptation, that Mr. Whitworth, long afterwards, was enabled to state that 'his breech-loading apparatus had, in no instance that he was aware of, been a failure. During the public experiments no accident or difficulty had ever occurred in working them.'[1]

Whilst occupied in making these guns on his own account, Mr. Whitworth renewed communications with the War Office, the late Lord Herbert of Lea having succeeded to the charge of that department. In August 1859, he made suggestions to the Secretary of State, for utilising the existing stores of ordnance by hooping them, and increasing the number of angles in the rifling from a hexagon to a decagon, so as to bring the reduction of strength in the barrel to a minimum. But, notwithstanding this and other offers of cooperation, the War Office was apparently so little inclined to encourage his efforts that in September 1859, they refused his request to be furnished with copies of the

[1] *Letter to the Times*, October 29, 1861.

official reports on rifled ordnance made up to that time by the Ordnance Select Committee. It was arranged, however, that early in the following spring he should have the opportunity of trying the powers of his new gun in penetrating iron plate.

As no reserve was manifested relative to the works in progress at his own factory, public interest became excited to learn the results of experiments from which so much was expected, and at length, within little more than a year from the commencement of operations, he was provided with a series of field guns, 3, 12, and 18-pounders, which together with an 80-pounder were announced to be ready for immediate trial.

The western coast of England, from the boundary of Cumberland to the estuary of the Dee, presents one unvarying feature, in the long and level plains of sand that mark the junction of the land and sea. They are occasioned by the rivers that descend from the highlands of Yorkshire and Westmoreland, and those which in the south drain the mountain regions on the confines of Wales. These streams come down laden with earthy deposit, which owing to contending currents they are unable to carry out to sea, and this settling in comparatively still water, forms banks, that are left bare between every tide. From these the sand dried by the sun is driven inwards by westerly winds, before which it may occasionally be seen running swiftly like the current of a river towards the shore, where it piles itself up in mounds, that are speedily covered by bent

and other hardy grasses that live in such exposed situations.

One of the most remarkable of these formations is the low coast of Lancashire, between the Ribble and the Mersey, an almost unbroken line of sand many miles in extent. From the shallowness of the water ships seldom approach close to the shore, and human habitations are rare, except where villages have been built for the summer residence of bathers. It was a level expanse of this dreary shore within a short distance of Southport that Mr. Whitworth, by permission of the Admiralty, selected for the trial of his guns. No place in the kingdom can present equal advantages for experiments with artillery, the range being immense, and the ground so level that the guns had to be raised on a platform in order to retain sight of the target or any other mark at a distance of three or four miles.

Here, early in the spring of 1860, he took up a position for his park of artillery on the beach; and huts for himself, his assistants, and ammunition were constructed amongst the sand-hills near on the shore. The trials occupied five days between the 15th and 24th of February, and on each occasion the railroad brought crowds of eager spectators, who ranged themselves in groups along the strand; an open space around the guns being enclosed by stakes and ropes and kept clear by police. The direction in which the firing was to take place was south, towards Formby, and this was denoted by a line of tall poles 1,000

yards apart with shorter ones at each 100 yards between; the whole extending over 10,000 yards, and thus marking out a range of something less than six miles.

The success, as described by the 'Times,' was 'astounding, and the event looked forward to with so much eagerness by artillerists and engineers, surpassed their most sanguine expectations. The accuracy and length of range were totally beyond what had ever before been attained, and the greatest results of the Armstrong gun were likely to be surpassed by the ordnance of Mr. Whitworth.'[1]

The experiments were so arranged as to exhibit not only the range of the new ordnance but the accurate flight of the projectiles. The smallest of the guns, the 3-pounder weighing only 208 lbs., fired at an elevation of 35°, threw a shot to the distance of 9,688 yards, or a little more than *five miles and a half.*

This was an achievement never before accomplished by any gun of any calibre. 'The greatest range previously reached by any Armstrong gun was 9,130 yards, and this was with a 32-pounder fired with 6 lbs. of powder at an elevation of 35°.'[2] It afterwards 'attained the astonishing range of 9,175 yards,'[3] but even this was 500 yards short of the performance of the Whitworth 3-pounder at Southport.

[1] *The Times*, February 17, 1860.

[2] *The Times*, February 20, 1860.

[3] See *Report of the Committee of the House of Commons on Ordnance*, 1862. Appendix, No. 3, p. 167, note.

One characteristic feature of these trials and one specially satisfactory was, that the result of every shot fired was measured and recorded on the spot; so that for the first time the public were enabled to see and appreciate the effect of consecutive firing from rifled ordnance, in the presence of impartial spectators.

The Secretary of State for War in moving the army estimates, whilst the trials were still in progress at Southport, stated that compared with this display of the Whitworth gun that of Sir William Armstrong 'might shoot a little short, but Sir William has not yet made a gun with a view to the special object of range. He said to me a few days ago, when speaking of the Whitworth gun, "That gun will no doubt beat mine in range, if it is made for range; but I will make one for range also, and you will then see what I shall do with Mr. Whitworth's." This,' continued Mr. Sidney Herbert, 'is perfectly fair. Sir William Armstrong is not the man to be daunted by a difficulty, and there is no doubt that whatever happens we shall have from him the best and most admirable gun that can be made.'[1]

But in range Mr. Whitworth has since surpassed the startling performance of 1860; his 12-pounder gun having sent a ball 10,300 yards, or very little short of *six miles*. The gun promised by Mr. Herbert has not yet been produced. In fact, almost simultaneously with Mr. Sidney Herbert's announcement, Sir William Armstrong, in addressing the members of the Institution of Civil

[1] *House of Commons, The Times*, February 18, 1860.

Engineers, questioned the value of any increase of range beyond that already attained, which the military authorities agreed was even more than sufficient for all field operations. 'The public,' he said, 'is always captivated by the attainment of long ranges, but great delusion prevails on the subject.' Such extreme distances render accuracy of aim impossible. The real struggle will always lie within a distance of 2,000 yards, and 'the fact is that, however perfect the weapons may be made, the fate of a battle will never be influenced by very distant firing.'[1]

These views of Sir William Armstrong as to range seemed to differ from that of the Committee of 1858, by whom his own gun was selected for the service, and who recommended it for adoption in consideration of 'its extraordinary powers of range combined with an equal precision of fire,' and under the belief that its 'range was probably the greatest on record.'[2] In justification of this course, Colonel Lefroy has given his opinion that length of range is more or less identified with precision of fire. 'To a certain extent,' he says in his Report on the State of Rifled Cannon, '*the question of accuracy may, in the first instance, be merged in that of range*, for whatever construction will send an elongated projectile of a given weight farthest, with the same charge, must necessarily have the advantage in

[1] *Proceedings of the Inst. of Civil Engin.* 1860, *Discussion on the Construction of Artillery*, p. 124.

[2] *Report of the Select Committee of the House of Commons on Ordnance*, 1862. Appendix, No. 3, p. 167.

point of accuracy, because it implies the greatest steadiness of the axis, and the least amount of irregular disturbing causes.'[1]

In this explanation Colonel Lefroy has the concurrence of Sir John F. Burgoyne, who has declared that 'great length of range, if not of so much importance in itself, is valuable as an indication of other qualities. It is a proof of superior accuracy, and above all it gives the power of firing *at lower angles of elevation.*'[2]

Mr. Whitworth, in reply to the observations of Sir William Armstrong, expressed his 'surprise to hear range undervalued by him. Without attaching too great importance to mere range, it must be admitted,' he said, 'to be a very good measure of what the gun could do. If, at an elevation of 7°, the range of the fluted gun was 2,495 yards, and the range of the hexagonally rifled 3,107 yards, *the trajectory of the latter was flatter*, and the errors in judging distance were of less importance, as during a greater portion of its flight the hexagonal projectile was nearer the ground. The gun which had the longer range and the flatter trajectory was more likely to hit a distant object than one which had one-fifth less

[1] *Report, &c.*, Appendix No. 1, p. 143.

[2] *Proceedings of the Inst. of Civil Engin., Discussion on the Construction of Artillery*, 1860, p. 68. This was in strict conformity with the dictum of Sir Howard Douglas, that the great object in the modern science of gunnery is to construct guns possessing the greatest power of range; '*the trajectories of which shall be as low or as flat* as possible.' *Naval Gunnery*, part iii. chap. v. p. 224.

range for the same elevation.'[1] In a letter to the 'Times,'[2] he disclaimed the idea of making range the main object, and treating other qualities as merely subordinate; and the farther experiments at Southport seemed to sustain his assertion, that accuracy and precision were equally possessed by his guns. In the course of Mr. Sidney Herbert's speech above quoted, delivered whilst these trials were still going on, he described what may be assumed to be the best results as regards precision obtained by the Armstrong gun up to that period. The last gun made by Sir William, he said, was a 12-pounder, and in four shots at 7° elevation, and with a range of from 2,465 to 2,495 yards (the difference in range being 65 yards) *the greatest difference in width was three yards.* With the Whitworth gun of the same calibre, and fired at the same elevation, on February 21, 1860, the range was from 3,078 to 3,107 yards (the difference in range being but 29 yards), whilst the difference in width was only *one yard and two-thirds.* 'As to precision, therefore, taking the whole, the Whitworth shots would have struck upon an area of 42 yards long by 5 feet wide, as against the Armstrong average of 70 yards long by 9 feet wide; and the whole of the Whitworths would have hit not within a *nine*, but within a *six* feet vertical target.'[3]

Nor was the performance of the Whitworth 80-

[1] *Proceedings of the Inst. of Civil Engin., Discussion on the Construction of Artillery,* 1860, p. 139.
[2] *Report, &c., The Times,* Feb. 28, 1860.
[3] *Report, &c., The Spectator,* March 7, 1860.

pounder less satisfactory; at an elevation of 7°, its shooting would appear to have been even more accurate than that of the 12-pounder. The range attained by it was about *two miles*; and, out of four shots, three fell within *an area of sixteen yards long by one foot wide.* The lateral deviation did not exceed 6 feet in the two extremes, and this, it was stated, was due, at least in part, to the unsteadiness of the wind.[1]

In addition to the British officers present at Southport, the trials were attended by French artillerists, and scientific military men from Austria, Sweden, the United States, and Brazil; and at the close of the day the expression of opinion was unanimous as to the facility with which the guns had been loaded and

[1] One ground of complaint against Mr. Whitworth's projectiles, in the early stage of his experiments, was 'their large and rapidly increasing deflection to the right' (see *Report of the Committee of* 1858). This tendency was not peculiar to them alone, it was apparent in the Armstrong projectile as well; and Sir William, in the statement which he made, descriptive of his own gun, before the Institution of Civil Engineers in 1860 (p. 179), ascribed its development in both instances to the true cause, the action of air on the rifled surface of the shot. Mr. Whitworth, when questioned on the subject by Sir John Hay, M.P., before the Committee of the House of Commons in 1863, said (question 2558): 'That is one of the objections raised to my gun and projectile at that time, and I can only express my surprise at such an objection being made, because we find that *it depends entirely on the direction of the wind*; the shot will go to the left or to the right just according to the wind, and, therefore, I maintain that it is no objection at all.' In proof of the entire correctness of this explanation it is sufficient to say, that whereas the Committee of 1858 described the deflection as 'large and rapidly increasing to *the right,' The Times*, in an account of the experiments at Southport, correctly stated that the deviation was to *the left*, and that this arose from 'a rather strong wind which set in from the sea.' *The Times*, Feb. 17.

handled by Mr. Whitworth's own people, and the rapidity with which they were discharged and reloaded.[1] 'There was no heating worthy of notice, either at the breech or the muzzle, no sponging or cleaning of any kind, and though, of course, the smell of powder was in the barrel, the gun was as clean after the firing was over as before it commenced.'[2] One foreign officer, doubtful of the closeness and security of the breech-loading apparatus, held a white handkerchief over the screw of the breech before the 80-pounder was fired, in order to satisfy himself of its perfect tightness, and after the discharge he looked with evident astonishment and satisfaction at the unsullied cambric.[3]

It had previously been imputed, as a defect common to all conoidal projectiles, that that form is unfavourable to *ricochet*, for which nothing was so suitable as spherical shot.[4] 'Ricochet' is the term applied to the series of rebounds made by a ball after the first graze; it may be regarded as a means of inflicting damage on

[1] *The Times*, Feb. 17, and Feb. 27, 1860.

[2] *The Times*, Feb. 17.

[3] *Letter to The Times*, March 3, 1860.

[4] Sir Howard Douglas has given some very curious instances of the unspent power of a ricochetting ball. 'At the siege of Burgos,' he says, 'our shot having been all expended, soldiers were employed and paid for picking up the balls fired by the enemy, to be used against them, regardless in such an emergency of the difference of windage. Many of our soldiers were seriously hurt, some it was said killed, in attempting to lift 16 lb. and 24 lb. shot, which appeared to be rolling like cricket balls, and as if they might be easily stopped. One soldier tried to do so with his foot, but it fractured his limb, and threw him down severely contused, and rolled on with a momentum, though with very little velocity, which would have done great damage to troops.' *Naval Gunnery*, part iii. ch. v. p. 232.

troops or artillery, who cannot be otherwise reached; and its value, both in land and naval actions, has been always appreciated when in the direct line of fire. In all elongated projectiles, but especially Mr. Whitworth's, ricochet is said to be prejudiced by the system of rifling, which imparts a tendency to deflect.[1] This statement is only to a certain extent correct: it is, I believe, true that elongated shot are incapable of ricochet at sea; and that all rifled shot fired *à ricochet* are more or less turned from their course when penetrating soft or wet sand, but not usually when striking comparatively hard ground. At Southport, Mr. Whitworth demonstrated that conical shot would ricochet well, and at a subsequent discussion at the Institute of Civil Engineers, he stated that, having tested both, he gave it a preference in this respect over spherical shot.[2] Sir William Armstrong, as the result of his own experience, states that at ranges within which smooth-bore guns are effective (as regard ricochet) the rifle projectile does very well: at least his own does. 'There is no difficulty,' he says, 'in making a rifle propel ricochet at a low angle, and it is only at high angles that they go wild.'[3]

[1] See note on this subject, *ante*, p. 200.

[2] *Proceedings of the Inst. of Civil Engin.* 1860, *Discussion on the Construction of Artillery*, p. 156. In July 1860, during subsequent official trials with the Whitworth guns, an eyewitness, whose report appeared in the *Manchester Guardian*, July 26, says, 'The ricochetting both of shot and shell was, professionally speaking, "beautiful;" that is they touched and rose from the ground many times, and never high, so that amongst bodies of men or horses they would have "told" constantly and well.'

[3] *Evidence of the House of Commons' Committee*, 1863, 3166.

The general result of the Southport trials, the 'Times' of February 20, 1860, summed up as follows:—'As regards range and accuracy, Mr. Whitworth's ordnance have as yet distanced all others; and the difference in those respects between his guns and Mr. Armstrong's, though not very great, is, in truth, of the utmost importance. The superiority is due to the form of projectile, and the pitch and manner of rifling adopted by Mr. Whitworth; and it is upon these points, and on the simplicity of the arrangement of the breech-loading apparatus, that the contest between them will turn.'

One triumph, at least, Mr. Whitworth had achieved by this display—he had successfully vindicated his professional reputation, and removed the reproach incautiously cast upon it the year before by excluding his 'principle' of rifling from farther notice by the authorities at the War Office. That principle was so rapidly reinstated in public confidence that, even before the Southport trials were ended, Mr. Sidney Herbert assured the House of Commons that, as between the two systems of Sir William Armstrong and Mr. Whitworth there was so slight a difference that, 'whichever of the two rival inventions wins, *we are perfectly safe*.'[1]

But, as regards the government of the country, an embarrassing conjuncture had arrived; the event, the probability of which had been foreseen by the Earl of Derby in 1858,[2] had arrived sooner than was expected,

[1] *House of Commons*, Feb. 18, 1860.

[2] See *ante*, Part II. chap. iv. p. 145.

and, notwithstanding the apprehension expressed by Sir James Graham, it remained unprovided for; a gun, which in certain respects was represented to be superior to that already adopted by the War Office, was now at the disposal of the Government. But the difficulty had become palpable of superseding the one, if necessary, or even of instituting an unimpeachable trial for the other. The previous choice of the Armstrong gun, would be practically condemned should the amended judgment prove to be in favour of the Whitworth; and that judgment, if promptly acted upon, would involve the country in the cost of a new 'transition,' after the expenditure already incurred in erecting factories and providing stores of ammunition and ordnance.

A trial, however, appeared inevitable; and, within one week from the close of the practice at Southport, Mr. Whitworth addressed the Secretary of State for War, explaining the points of difference between his own guns and those of Sir William Armstrong, and desiring to have their comparative merits tested. To this Mr. Sidney Herbert at once assented, *and thus, within little more than a year from the announcement of that decision of the Committee on Rifled Ordnance, in* 1858, *which ought to have been convincing and final, the War Department found itself constrained to reopen the whole enquiry, by authorising a new trial, which was substantially an appeal from the unsatisfactory finding by the previous tribunal.*

This renewed trial however never took place, owing

to the following circumstance. The judges whom the War Office proposed to nominate, were the Ordnance Select Committee of the War Department, whose great professional experience invests their opinions with becoming weight, especially when the Secretary of State happens to be a civilian. One member of that body, Sir William Wiseman, R.N., had been also a member of the Select Committee who in 1858 had decided in favour of the Armstrong gun. The experiments were to be carried on at Shoeburyness, and the programme was to be drawn up by the Ordnance Committee. Mr. Whitworth in reply to Mr. Sidney Herbert's communication, whilst adverting to the fact that the Committee whom he had now to convince were already more or less committed to preconceived views; and that experiments of indefinite length were to be conducted on the parade ground of the rival gun with which his was to compete, said he was, nevertheless, prepared to accept the ordeal, provided only that certain conditions equally applicable to both parties were complied with. He stipulated for such a course of experiments as would demonstrate the power of each gun, independent of the skill of the artillerymen who might be told off to handle them. He required that the experiments should be continued from day to day till completed; and suggested that instead of Shoeburyness they might take place on some new and untried ground, and that facilities should be given for the presence of scientific civilians as well as military officials.

A farther request of Mr. Whitworth was, that each

party was to be at liberty to employ his own men in firing his own guns. This was refused; the War Office agreed to certain modifications in the original draft, but the majority of Mr. Whitworth's proposals being considered inadmissible, he was eventually compelled, on finding that no section of the necessary experiments could be closed and reported on within a reasonable time, to acquaint Mr. Sidney Herbert that his health would not enable him to enter on an interminable contest, nor would his professional engagements permit it. He, therefore, declined to proceed under the conditions sought to be imposed.[1]

Meanwhile the 80-pounder gun which had excited so much astonishment by its performance at Southport, was taken thence to the Thames, in order to try the force of the flat-fronted projectile, which Mr. Whitworth had recently invented,[2] when fired against the armour-plate of a vessel of war. The occurrences of that day, one of the most memorable in the annals of modern gunnery, will be described in another place; here it is only necessary to state, that the projectile in every

[1] For an account of these negotiations, and the causes of the failure, see the evidence of General St. George, before the Committee of the House of Commons on Ordnance, in 1862. (Questions 2708-9, &c.) 'On one occasion,' said the General, 'when I went to the Admiralty, Mr. Whitworth was there; and when we came out, he himself told me that he felt obliged to decline the trial; he said he had not much *confidence in the Committee*. He said he should wish the matter referred to one individual; he had no objection either to myself, or *any other competent judge*; but he preferred the matter being referred to an individual rather than to a Committee.

[2] See *ante*, p. 122, and *post*, Part III. chap. iii. p. 260.

instance penetrated the iron sides of the 'Trusty,' and would have sunk her by a few more shots [1] had not the firing been stopped by the interposition of the Lords of the Admiralty who were present. Struck with the unexampled power of the gun, the Duke of Somerset suggested to the War Office the propriety of acquiring it for the Government, and the Secretary of State proposed to Mr. Whitworth to buy both it and the 12-pounder; but preparatory to their purchase he required farther trials with a view to forming a just opinion of their rifling and projectiles, and thus assisting to arrive at some final decision on the whole subject.[2] These farther trials took place at Southport; the War Office so far modifying their previous determination as to permit the guns to be worked by Mr. Whitworth's men, but with the stipulation that one half of the rounds were to be fired by artillerymen and sailors, in order to be assured of their convenience in working. The results were so satisfactory that the Government became possessed of both the 12 and the 80-pounder, the latter being forthwith sent to Portsmouth for practice, and the former to Shoeburyness.

The story of this 80-pounder, had the catastrophe by which it ended been less vexatious, would present an apt illustration of the difficulties before alluded to, with which Mr. Whitworth had to contend in struggling against military routine and exclusiveness. The renewed

[1] *Evidence of the House of Commons' Committee on Ordnance*, 1863, 5183, &c.

[2] Mr. Sidney Herbert, *Letter to Mr. Whitworth*, July 12, 1860.

trial took place at Southport, on July 25, 1860, General St. George and Colonel Bingham of the Royal Artillery being present on behalf of the War Department. From the report of these gentlemen, which was made public three years after,[1] it appears that the assent of the Secretary of State to allow the workmen who were familiar with the guns to fire them, at least in part, was only a good-humoured ruse of Lord Herbert to amuse Mr. Whitworth. 'The guns,' says the report of the two officers, 'were fired a few rounds by Mr. Whitworth's men previously, *but of these we took no note;* — they were then handed over to the Royal Artillery, and to seamen of the Royal Navy, and the practice recorded was carried on *entirely under our direction.*' The result was that General St. George and Colonel Bingham were of opinion that sufficient promise of advantage had been given to warrant the purchase of the gun, but they recommended a farther series of experiments '*to ascertain its real value.*'[2]

To determine this, the gun was sent to Portsmouth to have its merits tested by experienced hands on board one of the training ships. But it had scarcely arrived before Mr. Whitworth was written to to send a person to examine the breech-loading apparatus, which was stated to be out of order. The workman sent from Manchester discovered that the only thing astray was that the gun had been fouled at the breech by soot

[1] See Appendix, No. 43, to the *Report of the House of Commons' Committee*, 1863.

[2] *Ibid.* p. 476.

and dirt as well as by the use of bad oil; and that the sailors in their impatience had galled the screw by forcing it on in that condition. Shortly after, the gun, after firing 21 rounds on board the 'Excellent,' was found to have a crack in the inner tube between the breech and the muzzle. Mr. Anderson, the assistant of Sir William Armstrong in the Royal Factory at Woolwich, was sent to examine into the cause of this mishap, and along with him were associated two eminent engineers, Mr. Penn and Mr. Field. Their joint report,[1] far from imputing the catastrophe to any defect in the gun, ascribed it exclusively to an oversight in permitting an 'air space' to remain between the projectile and the charge. This may possibly have been occasioned by the rolling of the vessel, during which the shot, unprotected by a sabot, may have shifted its place.

The gun, being disabled by this misadventure, was shortly after sent to Woolwich to be there '*tested to destruction*,' by firing it with increasing charges in the bursting cell; — but these had no other effect, than causing the crack made at Portsmouth to expand, and they failed to rend the hoops, or blow up the gun. Yet this occurrence on board the 'Excellent' was afterwards adduced by its able commander, Captain Hewlett, as a reason for believing that 'the breech-loading arrangement of Mr. Whitworth

[1] Appendix, No. 53, *Report of the Ordnance Committee of the House of Commons*, 1863, p. 528. See also the Evidence of Mr. Whitworth, *Ibid.* 2996.

is faulty.'[1] Thus, an accident which ordinary prudence should have prevented, not only destroyed the piece, 'the real value' of which was to be tested; but served to defeat the avowed object of the Secretary of State in purchasing the gun for the Government, 'with a view,' as he said, 'to forming an opinion on the general principles of the Whitworth system, and thus assisting to arrive at some final decision on the subject.'

Good feeling and confidence were however restored between the War Department and Mr. Whitworth, whose assistance was solicited in experiments for determining the resistance of iron plates, as well as in the supply of guns and projectiles for departmental purposes, but with no indication of any intention to adopt them into the general service of the army or navy.

Mr. Whitworth, it appears from the published evidence, was at that time suffering from impaired health, the result of over-exertion and anxiety, and was therefore the more disposed to wait with patience the course of events which would lead to that searching and decisive enquiry which his own efforts had hitherto failed to obtain.

During the three years that followed the aspect of affairs apparently underwent no alteration. Mr. Whitworth continued, at his works, to manufacture such of his own guns as he had orders for from foreign

[1] *Evidence of the House of Commons' Committee on Ordnance*, 1863, Q. 3344, 3345, 3346.

governments, and at Elswick and Woolwich Armstrong guns of all calibres, from a 12 to a 300-pounder, were made to the number of 3000.[1] The 40-pounder, as already stated, was introduced into the navy in the spring of 1859, by a committee *of which Sir William Armstrong was a member*, and in the autumn of the same year the 110-pounder was added to the same service *without the formality of trial.* Sir William Armstrong, when asked in 1863, by what series of experiments that gun was approved, replied, '*None at all*, the pressure for rifled guns at that moment rendering it impossible to undertake any.'[2] In fact, it is stated by the Duke of Somerset, that Armstrong guns of every calibre were taken into the service without a trial in any instance, excepting that of the 40-pounder;[3]—on which latter occasion its inventor and Captain Noble (afterwards one of the partners at Elswick) formed two out of the four members of the committee by whom it was sanctioned.

The expenditure during the same period, at Woolwich and at Elswick, for the manufacture of Armstrong guns, carriages, and ammunition, exceeded *two millions and a half sterling*,[4] defrayed from the public treasury; whilst the outlay of all other inventors for experiments

[1] See *Report of the Select Committee of the House of Commons on Ordnance*, 1863, p. v.

[2] *Report of the Committee of the House of Commons on Ordnance*, 1863, p. v. *Evidence*, 3549.

[3] *Evidence of* the Duke of SOMERSET. *Ibid.* 5178.

[4] £2,539,547 17*s.* 8*d.* *Report, ibid.* p. v.

with rifled cannon, were borne exclusively from their private resources, although the results, in the instance of Mr. Whitworth, were thrown open gratuitously to the Government.

Notwithstanding the few opportunities for exhibiting its powers, public favour continued to be attracted towards the Whitworth gun, and one of the members of the special committee by whom it had been rejected in 1858, stated, on a later occasion, that from what he had then seen, he thought it in range and accuracy quite equal to those of Sir William Armstrong.[1] Theoretical opinions, however, continued to be expressed unfavourable to the principle of a mechanical fit for projectiles, in consequence of the liability to injure the bore by the friction of one hard metal upon another;[2] but, as the conjecture remained unsubstantiated in consequence of no sufficient trial having taken place, the apprehension was admitted to be 'technical'[3] and the Committee of the House of Commons, in 1863, has reported that 'no sufficient experiments have been tried to show whether it be correct.'[4] A similar fear was intimated, that the hard metal projectile might 'jam' in issuing from the rifling, but this was also inferential, and merely referable to the fact that a gun brought to this country from

[1] *Evidence of* Sir WILLIAM WISEMAN, Bart. R.N., *Committee of the House of Commons on Ordnance*, 1862, pp. 280, 281.

[2] *Ibid.* See Evidence of Sir WILLIAM ARMSTRONG, 3165, 3925. *Reports of the Committee*, p. viii.

[3] *Ibid.* 3925, 3928, 3932.

[4] *Report*, &c. p. viii.

Sardinia, by Cavalli, had burst in consequence of an iron projectile becoming wedged in the iron bore.'[1]

Towards the ordnance of Sir William Armstrong the growth of public favour was less assuring. Although the proportion of mischances was not, perhaps, greater than in the case of other pieces, they *appeared* to be greater from the largeness of the number of guns manufactured, and disappointment in any particular was felt in the ratio of exaggerated expectation. Distrust was engendered as to the material of which they were made, and although Sir William Armstrong has stated that out of *three thousand* guns, made on his system of welded coil, not one has ever burst explosively, nor failed except by a gradual process,[2] the feeling grew that it was not possible by welding to unite the forces of each coil so intimately as to withstand the rending force of the explosion, especially as the tendency of the longitudinal strain during discharge was to draw the coils asunder. In addition to this, the 'chase,' or forepart of the gun in front of the trunnions, was not thought sufficiently strong to withstand the external blow of a solid shot.

Sir Howard Douglas, looking to the delicate instruments and adjustments for laying the Armstrong gun with the degree of accuracy becoming its capabilities, and no doubt essential on land, came to the conclusion that these were utterly inapplicable on board a ship,

[1] *Committee of the House of Commons on Ordnance*, 1862, Evidence of Capt. Hewlett, R.N. 3312. 3313, 3337.

[2] *Evidence of the House of Commons' Committee*, 1863, 2974, 3163. *Report, ibid.* p. vii.

always disturbed more or less by uneasy motion; in correction of which the seaman's well-practised eye, and the rude habit of 'watching the roll,' would still have to be adhered to in actions, at whatever distance.[1]

Breech-loading was the fundamental feature of the Armstrong gun, inasmuch as his system of rifling the projectile is dependent on it; but breech-loading, which had so delighted the country by its novelty in 1858, declined in public confidence before two years elapsed, and 'the Government,' as was said by one of its advisers on the occasion, 'having deliberately adopted the Armstrong system, *must take the consequences of it.*'[2] In the Armstrong system the defects imputed had reference principally to the arrangement of using a separate piece of metal as a vent-piece, to be taken out every time the gun was fired, and replaced every time it was loaded, with all its inconveniences of weight, heat, and possible disruptions. Besides, such a device was pronounced to be unmechanical, inasmuch as it rendered that part of the cannon the weakest, which on every account ought to be the most solid and the strongest. Even supposing this objection, on scientific grounds, to be overruled, it was pointed out by more than one experienced observer, that men in the excitement of action with the enemy could never be expected to handle this unfamiliar instrument with such deliberate precision as to restore it in every instance to its proper

[1] *Naval Gunnery.* Part III. chap. v. p. 235.

[2] *Evidence of* Colonel Lefroy, *Select Committee of the House of Commons on Ordnance*, 1862, 289.

position, whilst the slightest irregularity involved the risk of destruction. Even scientific gunmakers, who, like Mr. Westley Richards, advocated the principle of loading at the breech, were forced to record their opinion that there were defects in this arrangement peculiar to the Armstrong gun, which had given rise to accidents calculated to discredit the whole system.[1]

But although mishaps with vent-pieces were made known from time to time, Sir William Armstrong demonstrated that the frequency of such occurrences was greatly exaggerated,[2] and that in no one instance had they been accompanied by loss of life, although it was no doubt true that wounds had been more than once inflicted.[3] In a discussion on National Defences at the Institute of Civil Engineers in 1861, he stated that 'in order to avoid the necessity of lifting the vent-piece, which in large guns became inconveniently heavy, he had long been endeavouring to make it slide out sideways. The first large gun he had made was constructed in this manner; but the objections which had presented themselves to that arrangement were, *first*, that the escape of gas at the breech, which in the vertical arrangement was of no importance, became a serious inconvenience when it took place from the side; and *secondly*, that in the event of the gun being fired before the vent-piece was screwed up, the mischief would be much more serious than if the

[1] *Loading at the Breech*, &c. by WESTLEY RICHARDS, p. 13.
[2] Sir WILLIAM ARMSTRONG'S *Letter to the Times*, Nov. 27, 1861.
[3] See also *Evidence before the Committee on Ordnance*, 1863, 3265.

opening were at the top. He did not, at that time, see how these difficulties could be surmounted, but he had since arrived at a construction, by which the object could be accomplished, without the liabilities described.[1] It is to be feared, however, that this new construction was not altogether successful, as accidents with vent-pieces continued to occur, and these chiefly with the larger guns; a result which eventually led Sir William Armstrong to the invention of the '*shunt*' gun,[2] in which breech-loading is altogether dispensed with. But this gun, as stated in the Report of the recent Committee of the House of Commons, is still only 'experimental,' and has not yet been taken into the service.

Naval officers began to manifest uneasiness at these untoward mischances,[3] and accounts from distant stations represented the increasing dislike of the men to handle weapons so dangerous and so capricious. In active service by land also, serious inconvenience was at first experienced from the 'stripping' of the projectiles, the lead coating of which, in some instances, became detached as it left the gun, and inflicted injuries on those within reach; but this liability was afterwards corrected, by the adoption of a process suggested by Mr. Bashley Britton, for ensuring its more intimate cohesion with the iron body of the projectile.

[1] *Proceedings of the Inst. of Civil Engineers*, 1861. *Discussion on National Defences*, p. 94.

[2] See Part III. chap. iv. pp. 306, 308.

[3] See *Letter of* Admiral HALSTED *to the Times*, Oct. 15, 1861. *Evidence of* Admiral SYDNEY DACRES, *Ordnance Committee*, 1863. 3182, &c.

Murmurs, complaints, and alarms grew so frequent on these and other points, that at length, towards the close of 1861, the publications devoted exclusively to mechanical art urged strongly the imminent necessity of investigation. The subject, thus indorsed by scientific authority, was taken up by the press, and the 'Times,' accepting the fact of the existence of these apprehensions, recommended enquiry without hesitation or delay. 'By boldly grappling with the cause we gain one of two advantages: if the Armstrong gun be found really efficient in spite of all said against it, we shall recover our confidence; and should it be found untrustworthy, we can at once look about for a substitute.'[1] The allegations alluded to imputed to the Armstrong gun the inability to bear rapid firing; that however effective when discharged only at intervals and carefully handled, in actual warfare, the metal would become heated, the delicate screws would no longer fit, and the piece would become disabled. Besides this, it was added 'graver defects are now said to have been discovered: *muzzles* as well as vent-pieces have been blown away, and the gun is, in fact, alarmingly liable to fracture.'[2] For these and other questions 'we require a fair and fear-

[1] *The Times*, Oct. 9, 1861.

[2] 'While almost every witness has borne testimony to the superior accuracy and range of the Armstrong guns, great doubts have been expressed as to whether they are not too delicate a weapon, and too liable to get out of order to be entirely relied upon in actual warfare. It must be remarked, however, that the officers who commanded Armstrong batteries in the late operations in China, found no difficulty in keeping *them in order in all weathers and under all circumstances.*' *Report*, p. vii., *Select Committee of the House of Commons on Ordnance*, 1863.

less examination, conducted without prepossession or bias.'

But a short period elapsed before the same authority was in a condition to state that the Secretary of State for War, Sir George Cornewall Lewis, had suspended for the present the issue of 100-pounder Armstrong guns, and had ordered such experiments to be made as would bring the efficiency of the new ordnance to decisive proof.[1] In the meantime, public attention was attracted to the relative performance of the Armstrong and Whitworth guns respectively, in an entirely new field, the operations in which it is necessary now to describe.

[1] *The Times*, Oct. 25, 1861.

PART III.

THE IRON NAVY.

CHAPTER I.

THE NATION RESOLVE TO CONSTRUCT A NAVY OF IRON.

WHILST the astonishment of England was excited by the startling discoveries made in relation to rifled muskets and field artillery, public attention had scarcely yet been drawn in another direction, in which these surprising inventions were destined to exert a paramount influence over the future interests of the United Kingdom. The question had not yet been popularly mooted as to the effect of these apparently invincible weapons on the *fleets*, and their consequent influence on the maritime supremacy of Great Britain.

The Admiralty, and those professionally conversant with warfare by sea, were of course instinctively alive to the revolution in naval construction, which had become imminent, when they saw ready for action guns that crushed granite into powder, and before whose irresistible bolts oak had become absolutely feeble and defenceless. But as yet, the nation, startled and fascinated by what was passing on land, had scarcely cast a glance towards what was impending at sea.

Alarm for the 'wooden walls' was, however, fully aroused by a highly interesting communication, in which

Sir William G. Armstrong [1] for the first time gratified public curiosity by a description of his own gun, and of the surprising force of his projectile, which was so formed as to be capable of being used as a shell as well as a shot, or even as both, inasmuch as it would penetrate as a shot before bursting as a shell. In the latter capacity, 5 lb. projectiles had been fired at 1,500 yards, against two targets, each 3 ft. thick, of rock elm, so placed, with an interval of 30 ft. between, that the one in front should exhibit the perforation made by the missile on entering, and the second the effects of the explosion within. The shells after passing through the first target, travelled four or five feet, and then exploded, scattering their splinters and hurling their pieces in every direction, and partially imbedding them in the timbers behind. 'If, therefore,' says Sir William, 'these were fired against a ship, they would first penetrate the side in their entirety, and then bursting, traverse the deck in fragments. Even these light 5-pounders, sending their shells from great distances through the sides of a ship and sweeping the decks with lumps of iron and lead, would produce destructive effects;— and a small swift steamer carrying a few such guns, might prove a very troublesome opponent to a large ship of war. But if the dimensions of the cannon were increased so as to adapt it for shells of twenty or thirty pounds,

[1] Sir W. G. Armstrong's *Letter to the Times*, January 1, 1857. At Portsmouth, towards the end of this year, Mr. Whitworth, in presence of some of the naval authorities, demonstrated the practicability of penetrating ships below the water mark by hollow shells of his construction. See *post*, p. 251.

still more terrible injury would be inflicted at great distances; and the ponderous artillery now used at sea would be of little service where opposed to the accurate and long-range firing of such rifled shell guns.'

It is curious to note the vast and rapid change which has taken place in our conception of naval warfare since this letter of Sir William Armstrong's was written. The bare idea of a shell of '*twenty* or *thirty* pounds' was then sufficient to inflame imagination by the dread of the 'terrible injury' it might inflict;—now shells of five times that weight have been fired with astounding effect, and these ere long may be superseded by others of still greater dimension. The 'ponderous artillery' of which Sir William spoke in 1857, has been superseded, not, as he then anticipated, by light shell guns, but by 100, 200, and even 300-pounders, and these in turn may give place to others of still larger calibre. But at the moment when it was made, his announcement so threatening and so incontestable had its natural effect upon public apprehension. There was still a vivid recollection of recent scenes of the Crimean war, when the navy of Turkey was destroyed at Sinope, by the Russian fleet firing Paixhans' explosive shot; and when, somewhat later, in the naval attack on Sebastopol, a British man-of-war, having received several shells thrown from the batteries, was set on fire and compelled to withdraw, not without some disorganisation of the crew.[1]

[1] 'One of our finest ships of the line having received three shells, by which eighteen men were killed between decks, was abandoned by

The disclosure of the powers of Sir W. Armstrong's gun cannot, however, be said to have taken the naval authorities of England by surprise. Observant and thoughtful seamen had previously been calculating the probable effects of rifled ordnance upon wooden ships of war. Even at the time when the risk was almost confined to shells plunging from the old mortars, alighting vertically on the upper deck,[1] and crashing downwards, perhaps even through the bottom, professional men were accustomed to say that a single shell well-directed might prove a ship's destruction.[2] But a far ruder shock had been given to the confidence traditionally reposed in British oak, when the sense of danger was aggravated by the dread of *shell fired horizontally* from heavy artillery; wooden ships then came to be regarded as little better than heaps of firewood; and the ablest officers conceived a wholesome apprehension of placing combustible fleets within the range of explosive shot.

Such men were duly familiar with the formidable

her crew, who left through the ports, and took refuge in a steam-ship alongside; nor could they be prevailed on to return to their guns.' *The Fleet of the Future*, &c. By J. Scott Russell, Esq., pp. 12–57.

[1] In Dr. Robison's *Mechanical Philosophy*, which remains a text-book, the great use of shells is described as destroying buildings, *breaking through the roofs of magazines*, &c., vol. i. p. 175.

[2] 'If *one* shell take effect, and be pitched into the place best suited for it, the results must be dreadful.' *Edinb. Review*, vol. xcvi. p. 516. M. Paixhans, in commenting on the destruction of the Turkish fleet at Sinope, in a letter published in the *Moniteur*, February, 1854, says: 'The English Admiral P. recently said to M. B. that if two vessels armed with these shell-guns were to fight, it might happen that in a few instants one would disappear in the air, and the other under water.'

nature of the missiles actually in use in the British navy. They knew the deadly capabilities of concussion shells, which, instead of an external fuse, had a mechanism within that released a striker on the instant of impact, spreading havoc like the springing of a mine. More dangerous than even these was the hollow shot filled with molten iron, the intense heat of which causes it to fall to pieces within a moment after penetrating a ship's side, when its fiery contents are discharged, burning and destroying as they flow amongst the timbers. Others contain a composition the combustion of which is so fierce, that they continue to blaze even after immersion under water. A rude shock having thus been given to the confidence traditionally reposed in 'heart of oak,' it is no matter for surprise that men aware of the formidable nature of such engines of death and destruction, whilst maintaining an heroic defiance of shot, should still fervently repeat the ejaculation of a brave naval officer, '*For God's sake keep out the shells!*'[1]

The justification of this alarm has since been manifested in the course of the present war in the United States, by the encounter between the iron-clad 'Merrimac' and the wooden ship 'Congress.' The first shell that burst within the latter killed every man at the nearest gun; another and another burst amongst the crew, and 'the ship was soon a slaughter-house. Operations were now out of the question. The wounded were in crowds, horribly cut up. The ship, too, was on fire. The shells

[1] See *The Quarterly Review*, vol. cviii. p. 557.

had kindled her wood-work in various places. Nearly all the guns were dismounted; the bulkheads blown to pieces; rammers and handspikes shivered, and the powder boys all killed. The inside of the ship looked like the interior of a burned and sacked house. Everything was in fragments — black or red, burnt or bloody. The horrible scene lasted about an hour and a half; and then she struck. The ship was already on fire, and it burned and blew up during the night.' Such is the published account by an eye-witness of the hideous catastrophe, which, in its combination of details, exhibits a realised epitome of all that had previously excited the apprehension of naval officers in England.

These and other minor incidents deeply implanted the conviction that wood, as the sole material for vessels of war,[1] was no longer to be relied on. Whatever difficulties might be opposed to the adoption of iron in its stead — however grave the objection to its weight and immobility, it was, at all events, exempt from the frightful liability to combustion, which caused wood to be shunned, and cast a doubt over the safety of its retention even when protected externally by plates of metal. So soon, therefore, as it came to be known that oak, however ponderous and powerfully framed, was no longer able

[1] Sir HOWARD DOUGLAS, even in the last edition of his work on naval gunnery, prepared shortly before his death, adhered to his original distrust of iron as a material for ships of war; but it is scarcely correct to say that he gave a deliberate preference to wood under all contingencies. In the ultimate power of iron to resist the penetration of shot he had no faith; but it is clear that he did not balance against this probability the certainty of the combustion of wooden ships by shell.

to resist the entrance of shell from the long range of rifled ordnance, as well as from the shorter one of the smooth bore, attention was earnestly turned to seek for protection against this new and formidable assailant, and iron at once suggested itself as the only effectual means of defence.

The idea of coating ships with armour was not, however, new. Nearly forty years before, General Paixhans (the inventor of the explosive shot which caused such havoc at Sinope), when his *canon-obusier* was adopted into the French service, in 1824, had anticipated Sir William G. Armstrong in the conviction that small craft equipped with artillery which discharged explosive and solid shot alike, would, under many circumstances, prove formidable antagonists to the old ships of the line, whose ponderous dimensions presented a mark, which it was next to impossible to miss. General Paixhans was so satisfied that one of his own shot, exploding on mere impact, would prove as destructive to timber as the springing of a mine, that he recommended to the Minister of Marine the expediency of casing ships of war with iron, sufficiently strong to protect them. But, at that time, the increased weight was supposed to be an insuperable obstacle to the use of armour-plating, and the suggestion was rejected by the naval authorities in France.

Twenty years later the plan was taken up (in 1845) by the American Government, but abandoned on the ground that although iron, five inches thick, was believed to be absolutely impenetrable by the heaviest

shot fired by the largest guns, with the greatest charge of powder and at the shortest distances,[1] the prodigious weight thus necessitated was felt to be incompatible with the other requirements of a sea-going ship.

In England, too, about the same time, ships built of iron, in comparatively thin plates, such as those in use in the merchant service, were introduced into the Navy, but with such indifferent results that the faith of the Admiralty was shaken as to its sufficiency; 'on account of the extensive ravages produced by the impacts of shot,'[2] and the vessels so constructed were dismantled as ships of war, and converted into transports and troop-ships. Between 1849 and 1852, a series of experiments were conducted at Portsmouth on plates of greater thickness; but although these trials were made with the old smooth-bore cannon, firing cast-iron shot, which was found in every instance to be split into fragments by the resistance of a plate of even *five-eighths* of an inch thick, no sufficient encouragement was felt to be given for the adoption of armour-plates in the Royal Navy.

In 1854, however, trials (instituted, it was said, at the suggestion of the French Government) were conducted on board H.M.S. 'Excellent,' at Portsmouth, on a target made of planks, strongly framed and faced with wrought iron $4\frac{1}{2}$ inches thick. This was fired at by 32-pounders at short ranges, and by 68-pounders at upwards of 1,200 yards. The former did little harm; but one heavy shot

[1] Scott Russell's *Fleet of the Future*, p. 65. Sir Howard Douglas in his *Postscript on Iron Defences*, p. 17, says the minimum was six inches.

[2] Sir Howard Douglas's *Naval Gunnery*, p. 133.

at long range cracked the plates in several places, whilst from a distance of 400 yards a continuous fire at last broke up the iron; and drove large fragments into the timber behind.

These results, confirming as they did those obtained from similar trials in France, brought the question of armour-plates to its first phase of success, and the two countries, then in alliance in the Russian war, agreed to furnish for its prosecution ten iron-plated batteries of equal force and like construction. Three of these, sent by France, were completed by October 1855, in time to take share in the assault upon Kinburn, where for hours they lay exposed, without injury, to the fire of the fortress. England followed the example, but so slowly that peace supervened, and none of the mailed gun-boats ordered by her were ready in time to undergo the test of an enemy's fire, either in the Black Sea or the Baltic.[1]

In 1857, anxiety on this matter was revived by intelligence that the Emperor of the French, expanding the original idea from mere floating batteries to sea-going ships, had ordered two frigates, the 'Gloire' and the 'Normandie' to be built of wood and covered with armour-plates; and that arrangements had been made for still further increasing his iron-clad fleet both in number and dimensions.

The English Admiralty, although sensible of the disadvantage of being thought to be distanced, in the

[1] One was, I believe, accidentally destroyed by fire in the builder's yard.

race for naval supremacy, exhibited no unquiet precipitancy. Less satisfied as to the absolute safety of iron than convinced of the insecurity of wood, they took time for deliberation; and at length, in 1858 (the artificers in the royal dockyards not having had any experience in constructing ships of iron), orders were given for armour-clad frigates of the first class, to be built by private contract in the Thames and the Clyde.

Meanwhile the science and professional skill of shipbuilders and others expert in designing constructions of iron were invited by the Government to assist in the development of the great national problem; experiments were resumed with increased earnestness and vigour in order to determine with accuracy the resisting powers of iron under the various contingencies of maritime war; and preparations were actively made for testing the relative powers of defence in armour-plate, and of attack in the newly-invented artillery.

CHAPTER II.

IRON SHIPS DEFY ARTILLERY.

IN the early stage of the experiments made to test the relative forces of armour-plates and artillery, prior to the building of the floating batteries of 1855, the conditions may be said to have been more or less in favour of the ship, inasmuch as whilst the iron submitted to trial was of the quality at that time esteemed the best, the ordnance brought to bear upon it was merely the old smooth-bore guns of the service; and the only projectiles in use were the common cast-iron shot, which, as has been already stated, invariably broke into fragments on collision with iron plates.

At the close of the Crimean war it was found prudent to prove the resisting power of our own iron vessels, and the floating battery 'Trusty' was prepared for being fired at off Shoeburyness. The experiment was, however, postponed; and a section of the vessel's side, viz. 25 inches of oak plated with iron 4 inches thick, was erected at Woolwich in the autumn of 1856, and practised against with wrought-iron shot; and although these failed to penetrate, they so crushed and fractured the plates, that pieces of them were driven

deep into the timber behind. In the same year, wrought-iron shot were again tried against 4 inches of steel securely bolted upon oak two feet in thickness, and again the guns displayed their superiority.

These facts were hardly known beyond official circles, and this was the state of the question when Sir W. Armstrong, in January 1857, published the remarkable letter which has been alluded to elsewhere,[1] descriptive of the structure and powers of his newly-invented gun and its projectiles. As before stated, this announcement served to stimulate public interest, and to impart a fresh impulse to the momentous enquiry instituted by the Government. In addition to what had previously been in progress at the Royal Arsenal at Woolwich, and to the experiments made by the 'Excellent' training-ship at Portsmouth, as well as those of the permanent Select Committee on Ordnance, a *Special Committee on Iron Plates and Guns* was appointed, whose investigations were carried on unremittingly at Shoeburyness down to 1860. Neither the proceedings nor the detailed reports of these several bodies, nor of others since constituted, have been officially communicated to Parliament or made known to the public; but the nature of their operations and the general character of their results have become more or less disclosed through the medium of the press.

And here it may be worthy of consideration, whether the advantages, said to be secured to the public service

[1] Part III. chap. i. p. 222.

by the system of secret experiments, are in reality of any value whatsoever. Numerous committees have been appointed in succession, to make trial of various schemes, at one time of defence, based on plans for iron-plating or for mail, at another of attack involving new forms of projectiles or artillery; but the results hitherto obtained lie, as yet, buried in elaborate records and unpublished proceedings and minutes of close committees. One supposed motive for withholding them is the large proportion of failures which they necessarily embody; but in the search for improvement failures have a value second only to success; inasmuch as they serve to warn off the adventurer from channels in which success has been proved to be unattainable. *Fully aware of their importance in this* point of view, all practical men concur in condemning the system that withholds information of this kind: not that credence is to be given to those allegations of partiality or injustice to which official secresy gives encouragement; but because concealment deprives the enterprising inventor of the beneficial warnings deducible from disappointment.

But to return to experiments, the effects of which are known. At Woolwich in 1857, *cast-iron* blocks upwards of two feet in thickness were fired at with cast-iron shot, which, as usual, crumbled to pieces; thus showing the inefficiency of that metal for attack as well as for defence: but when tried with wrought-iron projectiles, the blocks were broken up into lumps of from 10 lbs. to 80 lbs. weight; although the shot were

distorted and flattened by the collision. Again in 1858, a plate of wrought iron 8 inches thick was assailed, without much effect, by cast-iron shot at 450 yards; but it was crushed and destroyed, after repeated blows, by wrought-iron projectiles.

Nor were the general effects greatly different elsewhere. Before the close of 1858 the country had been astonished by the surprising accuracy and power of Sir William Armstrong's then largest rifled gun, a 32-pounder, which had exhibited an extreme range of over 9,000 yards, and it was resolved by the Admiralty to try the effect of its elongated bolts against the sides of the floating battery 'Trusty' itself, which, as already stated, had been vicariously represented by a target during the experiments above alluded to at Woolwich in 1856. This trial took place in January 1859 off the beach at Shoeburyness, on the northern shore of the Thames, when the 32-pounder, using charges of 6 lbs. of powder, was mounted on a gun-boat for the occasion. Fourteen shots in all were fired, some from a distance of not more than 50 yards, bolts being tried both of wrought and cast-iron and of steel; but two only, which happened to strike on joints of the armour, made indentations of a few inches; and as for the ship herself, she proved practically impenetrable by any efforts of this gun.

By September of the same year, Sir William's largest rifled gun had advanced to the size of an 80-pounder of 63 cwt., using a charge of 12 lbs.; and the 'Trusty' was again brought out to test her powers of resistance

against this truly formidable assailant. The firing extended over two days, at distances of 200 and 400 yards respectively; and at the former steel bolts of 6 inches in diameter and 14 inches in length, weighing 100 lbs., were used in some instances; but, to the general surprise, the result differed only in degree from that manifested in the January previous. Out of 22 shots fired, but 3 penetrated the armour sufficiently to effect a lodgement in the side, and of these only 1 entered the ship for a short distance, having struck near a previous shot-hole. The 25 inches of oak, scantily covered with 4 inches of iron, which formed the sides of the 'Trusty,' were thus found to present a complete protection for the guns and guns' crews within, against the greatest powers of artillery then known; and details of great practical value were elicited during this memorable conflict between the powers of assault and defence.

These were not the only results obtained at Shoeburyness. Targets were erected to represent in strength and shape the sloping sides of ships-of-war, iron of various degrees of density being bolted over oak firmly framed to form a ponderous backing, were fired at from different ranges, with various descriptions of shot and shell from guns of several kinds, but especially from Sir William Armstrong's 80-pounder; and the final impression left on the minds of the *Special Committee on Iron Plates and Guns*, was, that although comparatively thin plates of iron would suffice to break up cast-iron shell; permitting it to pass, if at all, only

in fragments, still these fragments were so formidable that little advantage could be said to be gained unless the plates were rendered sufficiently thick to exclude both these and cast-iron shot. *For all practical purposes, however, vessels clad with armour $4\frac{1}{2}$ inches thick were held to be invulnerable to any known shot at any ascertained range.*

In succession to the Committee on Plates and Guns, which closed its labours in the spring of 1860, another special *Committee on Iron* was afterwards appointed, composed partly of naval and military officers and partly of civilians of practical science; with instructions to determine by experiment the essentials of such iron plates as would best resist shot under all probable contingencies; and to record their opinions as to the best means for their production. But after twelve months of unrelaxed attention, and trials with iron of various thicknesses placed at every imaginable angle, secured by fastenings of every contrivance, and fired at with guns of every calibre then in use, and with projectiles of various materials, and of shapes as diversified, the feeling produced in the minds of the members of the Committee was that of surprise at the results; the unforeseen nature of which served to demonstrate the danger of speculating on the probable effects of untested theories. In fact, the phenomena exhibited by the collision of heavy projectiles fired from modern rifled ordnance against iron defences, were found to be something entirely new and peculiar, differing widely from any previously known species of mechanical action.

At the same time, certain facts were established of great interest and importance; for example, it appears that up to a certain point the resistance of iron plate to projectiles may be said to increase nearly as the square of the thickness: that is to say, a plate 2 inches thick will present a resistance *four times* as great as one of 1 inch, and one of 3 inches will be in the proportion of *nine to one*. Beyond 3 inches, however, the power of perfect iron plates had not been satisfactorily tested, inasmuch as experience had shown that, owing to the casualties incident to forging and rolling, the liability to imperfections in uniformity of density, which increase in proportion to the increase of thickness, had *yet to be overcome in plates beyond that dimension.*

The mere *momentum* of the projectile, when disassociated from other essentials, was also found to be an unreliable measure of the amount of destruction to be achieved by it; and even the influence of *form* and *material* remained undetermined, so far as regarded penetrative power, except in the instance to be presently alluded to,[1] in which a Whitworth 68-pound shot of a peculiar form passed through the side of the 'Alfred' at Portsmouth in 1858; but the cast-iron gun from which it was fired was unequal to the effort and burst on a second attempt.

As to the armour-plates, experiment showed that the softest and most yielding iron was that which encountered the projectile with the least amount of damage, steel and highly-hardened plates being more liable to

[1] See Part III. chap. iii. p. 254.

break up. So firm, however, was the general resistance of iron in all its aspects to the assaults of every species of shot, that after more than a year spent in assiduous observation, the Committee were unable to record any judgment without still more prolonged experiments.

At Portsmouth, where the trials were superintended by officers of the most extended experience in gunnery and animated by a personal interest in the issue, the conclusions were equally unsatisfactory. Experiments were made under conditions as nearly as possible analogous to the reality of maritime warfare, by attaching armour-plate to the sides of sound vessels actually afloat, but of a build no longer approved in the service. As a general rule the final results were the same; cast-iron shot, both round and cylindrical, broke into splinters against the inexpugnable metal, and wrought-iron succeeded in destroying the plates only after repeatedly bruising and rending them, or when by dexterous aim successive blows had been planted on a particular spot already fractured or crushed.

So sensibly was this felt, that the naval authorities at Portsmouth, after a long series of experiments simultaneous with those of special committees elsewhere, were forced to the conclusion that less damage was likely to be done by the clean penetration of one powerfully planted 32-pounder, than by the repeated blows of spherical shot from smooth bore guns, at shorter distances. It was clearly ascertained that at a range of 400 yards, wrought-iron plates 4 inches thick, such as clothed all the floating batteries then afloat, were

sufficient to resist for a considerable time every description of projectile, even 68-pound wrought-iron shot, and it was firmly believed that shell and red-hot shot would make no impression upon them. At ranges beyond 400 yards armour-plate were thought to be invulnerable, but at 100 yards the effect of solid projectiles was sensibly increased, the cast-iron 68-pounders having in one instance penetrated the wood-work as well as the iron; still, of these latter, none passed completely through, except such as struck in holes previously made.

There were some peculiar exceptions, which will be hereafter alluded to, where artillery reasserted its power, but so signal was the unshaken supremacy of the iron over the most impetuous attacks of guns and projectiles, that throughout 1860 and 1861, and even down to the first successful attack on the 'Warrior' target in the autumn of 1862, the conviction was as profound as it was general, that *victory remained on the side of the ships, and that the utmost force of rifled ordnance had been exerted against them in vain.*[2]

[1] Against the 'Erebus' floating battery.

[2] At Portsmouth, in August 1861, attempts were unsuccessfully made to destroy what was known as JONES' Angular Butt. As previous experiments had generally been made against plates in a vertical position or only so much out of the perpendicular as to resemble the side of a ship, this gentleman conceived the idea of so arranging the iron plates above the water line, as to form an angle of *fifty-two* degrees; from which, as he rightly conjectured, spherical and conical shot would glance off without penetrating. A series of trials was made by the officers of the 'Excellent,' and the result fully justified the anticipations of the projector. The firing was in every case at 200 yards' distance, with cast-iron bolts weighing each 110 lbs., from the Armstrong gun, with a charge of 14 lbs

As to cast iron, it was proved to be impotent either in the form of solid shot or hollow shell, and so early as 1861, it was confidently asserted of a steel bolt that although as often as it strikes an armour-clad vessel, it does more or less damage, such as 'scratch a plate or crack or indent it;—and although when you have done this once, you can strike the same spot a second, a third, or a fourth time, till by continual hammering, you may ultimately break it to pieces;' still to accomplish all this, and finally to make the ship a capture or a wreck, would require '*plenty of time, an inexhaustible arsenal of missiles, a calm sea, and no one to trouble you.*'[1]

This was not only the conviction of professional observers, but the prevalent feeling of the time. 'As it is proved,' said one of the leading organs of public opinion, 'that one inch of iron will stop the explosion of any shell,' it follows that 'if two iron-plated frigates meet each other at sea, shell-firing will be of little or no use, but the two vessels will hammer away at each other with their heaviest solid shot guns. If a plate is struck twice on or near the same place it may be cracked; if three times it may be splintered; and if four times, an entrance may be effected; but the

of powder; but although as many as six shot struck within a space of 21 inches by 12, the effect produced was absolutely insignificant, and after being hammered by sixteen blows, the plates were not pierced, nor was the wood-work materially injured.

There is, however, no reason to doubt that if, instead of conical and spherical shot, the trial had been made with flat-fronted projectiles invented by Mr. WHITWORTH (see p. 249), the result would have been different.

[1] SCOTT RUSSELL's *Fleet of the Future*, p. 10.

chances are one hundred to one against this ever happening in actual warfare.'[1]

This judgment appears to have been shared by some of those most profoundly acquainted with the subject, and most earnestly interested in the momentous question at issue. Sir William Armstrong, whose powerful cannon had been prominently employed in official experiments, frankly stated before the Institution of Civil Engineers in 1860, that 'up to that time no gun of his construction had satisfied the conditions requisite for thoroughly and completely punching through thick wrought-iron plates.'[2] In 1861, he repeated at Sheffield his assurance that iron-plated ships 'will effectually resist every species of explosive or incendiary projectile, as well as solid shot, from all but the heaviest guns, which can never be used in large numbers against them.'[3] And so lately as May 1862, he reiterated his opinion, that 'it may certainly be said that shells are of no avail against iron-plated ships, and that neither 68-pounder nor 110-pounder guns, with solid, round, or conical shots, are effective against them.'[4]

Capt. Hewlett, C.B., of H.M.S. 'Excellent,' after a long course of experience and observation, had also come

[1] *Quarterly Review*, 1860, p. 558.

[2] From the *Minutes of the Inst. of Civ. Eng. on the Construction of Artillery*, Feb. 14, 1860, p. 133. Sir William Armstrong added that 'there was no doubt it could be done with a special gun. It was only a question of bore and of hard material, such as steel, or homogeneous iron for the shot. But the expense of such materials would almost prohibit their use.'

[3] Meeting of Mechanical Engineers at Sheffield, August 1861.

[4] *Journal of the Royal United Service Institution*, vol. vi. p. 150.

to the conclusion that no description of hollow projectile discharged from any of the cannon tried up to that period, from a distance of 200 yards, could penetrate a ship protected by rolled iron plate $4\frac{1}{4}$ inches thick, nor could they be rendered capable of doing so. In short, that armour of that thickness was sufficient to exclude molten iron shells, and every explosive missile by which a vessel was exposed to the risk of combustion; however she might ultimately be found to be destructible by solid shot.

CHAPTER III.

WHITWORTH'S PROJECTILES PENETRATE ARMOUR-CLAD SHIPS.

IN the midst of the elation over the successful resistance of iron ships to the most powerful artillery, rifled as well as smooth-bore, that the service could then supply, one warning voice was uniformly and consistently raised, to deprecate premature confidence and to expostulate against inconsiderate outlay on armour-clad ships. Sir Howard Douglas, both incidentally in his treatise upon *Naval Gunnery*, and specially in a later work on *Iron Defences*, recorded his conviction (on grounds since rendered in some measure questionable) that as no iron less than $4\frac{1}{2}$ or even 6 inches in thickness would suffice to keep out shot, the carriage of such a weight would be found incompatible with the conditions of stability and flotation indispensable to the safe navigation of a vessel of war.[1]

[1] So far back as the 23rd April 1857, *The Times* had the foresight to predict that before long the rifled ordnance and improved projectiles of Mr. WHITWORTH would solve 'the question of driving holes in the four-inch breast-plates of floating batteries, and revolutionise the construction of artillery,' a prediction which it will be seen was fulfilled shortly after, when Mr. WHITWORTH, in October 1858, fired his flat-fronted shot through the armour-plate of the 'Alfred' from a range of 450 yards. See *post*, p. 254.

Speed and metallic protection Sir Howard regarded as qualities so antagonistic, that the one could only be attained by the surrender of the other; and that consequently in naval warfare the ship so overloaded would divest herself of the power to select the distance at which it might be most advantageous for her to fight. Besides which, he firmly believed that *in the long run*, the improved power of artillery would overcome the defensive properties of armour, and that victory as before would be found on the side of the gun. He lived to witness the verification of his own prediction in the latter particular; and the means by which that result were developed will form the subject of the present chapter.[1]

From the events already narrated it will be felt that in the early encounters between mailed vessels and artillery, the weak point of the latter, and the apparent immunity of the ship, was attributable less to defects in the guns employed than to the want of a *projectile* of such form and material as would endure concussion without fracture and effect a passage through iron-plate. Cast-iron was found to crumble into harmless nuggets; and wrought-iron bolts and cylinders were so warped and flattened by collision as to incapacitate them for penetration. Whatever injury such missiles inflicted was occasioned, not by piercing the armour, but by the ruder operation of bruising, and ultimately smashing it, by successive blows, skilfully planted and repeated on the

[1] Sir Howard Douglas, *Naval Gunnery*, p. 417, &c. *Iron Defences*, pp. 15, 19, 45.

same spot. As to shells and all other explosive or inflammatory missiles, they invariably went to pieces on the outer surface of the plates; and even in the case of Sir William Armstrong's 100-pound gun, when a shell was driven through 3 inches of iron, it passed not in the shape of a shell, to burst destructively within, but in a shower of fragments like grapeshot, into which it had been broken up by the mere force of the impact.

These consequences sustained, if they did not suggest, the declaration made at a later period by Sir William Armstrong, that what we were really in want of was an effective *projectile*, rather than a cannon to impel it. 'The projectile,' he said, 'should rule the gun, not the gun the projectile—for, as the shot had to do the work, it must evidently be proper, first, to determine what kind of missile was required, and then to devise the form of gun best adapted to throw it.'[1] This was the practical course adopted by Mr. Whitworth in 1855,[2] and besides it was strictly in conformity with the declaration made by the Duke of Wellington in a letter to the Marquis of Anglesea in October 1851, on the introduction of the Minié rifle, in which he observed that it appeared to him '*the first thing to do is to fix on the exact shape and construction of the projectile and its weight*; and *next* the mode of rifling the barrels in order to produce sufficient accuracy of practice.'[3]

[1] *Minutes of Proceedings of the Institution of Civil Engineers, Feb.* 1860, *on the Construction of Artillery*, p. 119.

[2] See *ante*, Part I. chap. iii. p. 38.

[3] *Committee of the House of Commons on Military Organisation*,

It was obvious that, for a projectile to penetrate armour-plate, what was sought was, first, a *material* sufficiently hard to clear a passage for itself, and sufficiently tough not to break up during concussion; and, secondly, a *form* calculated to maintain as long as possible a high initial velocity; together with the utmost penetrative power.

In the instance of the Whitworth-rifled musket, it had already been shown that its range and precision were not attributable to mere chance, but were capable of reduction to fixed mechanical laws; and in the same manner it was felt that the qualities which determine the efficiency of heavy ordnance under analogous conditions were equally amenable to unvarying physical principles.[1]

1860, p. 445. General BORMANN, of the Belgian service, the inventor of the metallic time fuse (*la fusée métallique Belge*), in his work on *The Shrapnell Shell*, in which he puts forward his claim to the invention of the fuse applied by Sir WILLIAM ARMSTRONG to his own 'Segment Shell,' says with some truth that the English press in discussing the Armstrong guns, 'rarely takes into account in connection with them the *projectiles* belonging to those guns, and when they do, the importance of the latter to the whole system has never had due consideration. The gun has generally been put forward so prominently as to exclude projectiles and fuses from view; as if the value of the system depended on the gun alone. This is a great error, for whatever be the system of ordnance, whether with smooth or rifled bore, *the projectile* has always a more extended influence on the efficiency of the fire than the piece that throws it.' BORMANN'S *Shrapnell Shell*, Appendix, p. 170.

[1] Among the practical benefits which have accrued to the public service from the improvements made in rifled arms within the last few years, we must not forget to note the enormous gain of substituting for the old rule of thumb (or what is called in Birmingham the 'knack') of the gun-maker correct and ascertained mechanical principles. It is said that but a few years ago the gun-maker, when for reasons unknown to himself he was unable to make his guns shoot, would give the stubborn

To this, however, exception was taken; it was urged that although it was easy to argue downwards, from results obtained in experiments on the resisting power of iron, it was hazardous to invert the process and to reason from experiments on a small scale, up to the results likely to be obtained on a great one. As the uncertainty of iron increases in proportion to its increasing weight, the quantity of gunpowder necessary to effect an object with a large mass being once ascertained, no difficulty presents itself in calculating the lesser quantity required for an object of less magnitude; but, on the contrary, it was held that the penetration of a half-inch of iron by a bullet from a rifle would prove to be a fallacious *datum* on which to rely for obtaining correspondent results with projectiles of heavier weight fired from pieces of large calibre against armour-plates like those of the 'Warrior.'

It was no doubt true that grand inventions in other branches of science had been made by induction from experiments on very reduced scales; but to this it was urged that the case of metal was influenced by qualities and attributes peculiar to itself; overlooking the fact that Wollaston achieved his great discoveries in metallurgy by manipulating almost infinitesimal quantities in crucibles no larger than a lady's thimble. If in later times the difficulties alluded to had been encountered by mechanists and engineers in search of the true form

barrel a blow of a hammer or 'a crook,' and then it would sometimes chance that in correcting the result of the blow the shooting was also improved.

for a projectile, the failure was to be ascribed not to any defect inherent in the process of inductive reasoning, but to the accidental oversight of certain conditions indispensable to true calculation and inference. In the instance of Mr. Whitworth, the inference from results on a small scale to those assumed on a great one, presented no practical impediment. 'In artillery practice,' he has given it as the result of his own trials, that 'experience enables conclusions to be drawn which go beyond the point when actual results are left.' 'My own experiments,' he says, 'with penetrating shell were chiefly made *with a 1-pounder* gun; its results were fully borne out by those of a *6-pounder* and a *12-pounder*; and though I had never tried the 70-pounder or the 120-pounder with shell before I went to Shoeburyness, *the results of the smaller guns enabled me to state beforehand with confidence what the guns and shells would do*.'[1]

The problem, so far as concerned projectiles, had not long to wait for a thoroughly practical solution, and this, too, was attained by taking the results of trials on a small scale, as the basis of confidence for success upon a grander one. In the long course of his experiments on the penetrating power of projectiles discharged from his rifled musket, Mr. Whitworth found that the conical bullet, when hardened by alloying the lead with a small portion of tin, was capable of piercing *more than thirty half-inch planks of elm.* But observant of the ordinary action of the *punch*, the flat-face and cutting edge of which, enable it to overcome the

[1] *Letter to The Times*, Oct. 11, 1862.

resistance of iron, by displacing only so much of the area opposed to it in the direction of its own axis as is covered by its disc, he ascertained that a steel projectile similarly formed with a *flat, instead of a conoidal front,*[1] was capable when fired from the same rifle, with only $2\frac{1}{2}$ drams of powder, of piercing through a plate of wrought iron $\frac{6}{10}$ths of an inch thick.

THE FIRST WHITWORTH STEEL PROJECTILE WHICH PENETRATED IRON PLATE.

For self-protection, Mr. Whitworth applied for and obtained letters patent in 1857 for this amongst other inventions for the improvement of artillery, but actuated by his desire to cooperate with the Naval and Military authorities in an investigation so intimately connected with the highest interests of the country, he gave the use of his flat-fronted projectile to Her Majesty's

[1] Like most other inventions, the question of priority has been raised in relation to flat-fronted projectiles—they are said to have been tried in France before they were resorted to in England. Captain NORTON claims the credit of having suggested them many years before Mr. WHITWORTH, borrowing the idea from the cross-bowmen of the middle ages, who are represented as using punch-headed arrows to perforate body armour.

Government; and hence Sir William Armstrong also was enabled subsequently to conduct experiments at Shoeburyness, with shot of this particular form.[1]

Enlarging the scale of his experiments, Mr. Whitworth realised the anticipation he had formed as to the practicability of penetrating heavy armour-plates, by means of this specially-adapted projectile, the peculiar action of which he thus described before the Institution of Civil Engineers in 1860. 'When the round-headed form of shot is forced against a thick wrought-iron plate it displaces the particles in a lateral direction, and has to overcome the great *lateral* resistance thus opposed to its passage. But in the case of the flat-fronted shot the resistance, which is direct and not lateral, is confined to the exact spot on which it strikes, and if the momentum be sufficient, and the particles of the projectile cohere, it punches a hole in the plate.'[2] To ensure this required cohesion, the material of which the shot is composed is homogeneous iron, which, when properly tempered, combines the toughness of copper with the hardness

[1] See *post*, p. 259. *Minutes of Proceedings of the Institution of Civil Engineers on the Construction of Artillery*, p. 136.

[2] *Proceedings of the Institution of Civil Engineers on the Construction of Artillery*, p. 109. The principle on which the penetration of iron plates by flat-fronted shot depends, was thus adverted to by Mr. George Redford, in a paper read before the British Association in 1863, in which he says: that, in addition to the concentration of the force, and its direct instead of lateral application, *time* may be an element of success, and that penetration may be facilitated by the suddenness of the impact. Force slowly applied is gradually absorbed by the whole of the mass struck, but where the blow falls with the rapidity of lightning, one portion of the mass gives way before the absorption of others can come to its relief.

of steel, and is qualified to penetrate wrought-iron plate without being distorted, or breaking into fragments at the moment of collision.

Armed with this new weapon, Mr. Whitworth was in a condition the year following his discovery to acquaint the Lords of the Admiralty in 1858 that he had penetrated *thick iron plates* with these flat-headed projectiles, whilst spherical shot of the same material, fired from a gun of equal bore, made only a slight indentation. 'This simple form,' he added, 'had also been found the best for *penetrating water*, whilst its range through the air excels that of spherical shot by more than 50 per cent., the charge and elevation being the same in both cases.' He therefore ventured to recommend that a 68-pounder should be rifled on his system, with a view to trials on a larger scale.

The experiments which established the fact that the flat-fronted projectile would penetrate a ship under water, were made at Portsmouth in 1857, with one of the three 24-lb. howitzers which he had rifled for the Government.[1] It had previously been determined by many actual trials, that a round-shot fired from a gun so depressed as to strike the water, instead of continuing a direct course through it, invariably rose to the surface, and this even when fired at a comparatively high angle; so that, below the water-line, even wooden ships were considered to be practically invulnerable by

[1] See *ante*, Part II. chap. iii. p. 122. Mr. Whitworth's account of this exploit will be found in the *Evidence of the House of Commons' Committee on Ordnance*, 1863, p. 107.

spherical shot. But the flat-headed bolt, when fired on the occasion alluded to, passed obliquely through thirty feet of water, and entered timber three feet below the water-line, penetrating 8 inches of oak beams and planking. 'This peculiar faculty,' says Sir Howard Douglas, 'may prove destructive if not fatal to a ship-of-war by a perforation so low that it cannot easily be stopped: and if that perforation be made through iron-plate, it could neither be plugged from within, nor could the "parasol plug" be successfully applied to it from without.'[1]

Another property of the Whitworth flat-fronted shot is its ability to pass through iron plates inclined at an angle of $57\frac{1}{2}°$; for, although the centre of the front is slightly rounded, the edge is left comparatively sharp, and therefore bites the surface, which it ploughs up, notwithstanding that the resistance which it encounters is apparently increased by the diagonal thickness of the plate. It is hardly possible to over-estimate the advantages attendant on this property of the flat-fronted shot, in not glancing off from an inclined surface. It cannot be expected that one shot in a hundred fired at a vessel in motion will strike it 'full'; since owing to the outline of the ship's side, its situation at the instant, or the position from which the gun itself

[1] Sir Howard Douglas on *Naval Gunnery*, p. 424. Sir Howard says the thickness of the ship's bottom through which the shot passed under water was 'twelve or fourteen inches' of oak. The property of flat-fronted shot to penetrate water without deflection is said to have been discovered by Captain Thomas Roys of Liverpool, who made flat-headed shells for the purpose of shooting whales in the North Sea.

may be fired, the chances are that the vast proportion of the shot will hit at an angle more or less inclined to the plane of the object aimed at. In all such cases, as the tendency of spherical or round-fronted projectiles is to deflect and glance off, the superiority of one which lays hold of and penetrates the surface, even at an angle of considerable obliquity, is manifestly great.[1]

Mr. Whitworth's suggestion of rifling a 68-pounder gun, to be employed on further experiments with this formidable missile was acceded to by the Government in 1857, and as stated elsewhere[2] a *cast-iron* block similar to those ordinarily used in the service was sent to him to be hexagonally rifled. It is to be regretted that a trial so important should have been attempted with a gun, the metal of which was so little to be relied on, since the failure of the material was sure to bring discredit on any system, however scientifically applied to it. But it must be borne in mind that, at that time, the processes by which forged iron has since been made so greatly to supersede cast were not yet matured; and that homogeneous metal had not then been brought to its present degree of perfection.

The Government cast-iron gun, rifled on the system of Mr. Whitworth, was accordingly tried at Portsmouth

[1] Experiments designed to exhibit this peculiar property of the Whitworth flat-fronted projectiles were made by the Committee on iron plate with perfect success at Shoeburyness in November 1862, shell as well as shot having been driven through iron plate $2\frac{1}{2}$ inches thick, inclined at an angle of 45 degrees. An account of this trial will be found in the next chapter, p. 297.

[2] See *ante*, Part II. chap. v. p. 166.

in October 1858, against armour-plate *four* inches thick fastened against the side of H.M.S. 'Alfred,' and the firing took place from the deck of the gunboat 'Stork.' After a round of cast-iron shot to obtain the range, the flat-fronted hexagonal projectile was fired, and at a distance of 450 yards, with a charge of 12 lbs. of powder, a bolt made of homogeneous iron, weighing 68 lbs., *twelve* inches long, with a diameter of upwards of *five* inches in the middle, was driven clean through the armour-plate, and through the timber side of the ship, tearing asunder the woodwork within, rending the beams, and falling on the deck about two feet from the opening through which it entered. The projectile itself was but slightly altered in form by the collision.

To effect its passage, the flat end of the shot, cutting its way like a punch, detached and forced forward a saucer-like lump of iron somewhat larger than its own circumference; and left behind in the outward plate a hole six inches in diameter.[1]

A cast-iron shot was then fired, which broke in pieces after indenting the plate; but on the next day the cast metal of which the gun was made gave way, and it burst with extreme violence, large pieces of it being hurled into the sea. This disaster, however, did not occur until after the great problem had been settled as to the inability of armour to resist the assault of shot of that peculiar description; nor until the

[1] See an illustration at p. 291 of a similar shot, and the piece of plate so punched out by it.

grand fact had been demonstrated, of the power of the Whitworth *flat-fronted* projectile to cut a passage for itself through a plate of forged iron, nearly equal in thickness to the diameter of the projectile which pierced it.[1]

Conjecture varied as to the precise cause of the bursting of the gun; although a sufficient explanation may be found in the nature of the cast iron of which it was formed, the inherent weakness of which rendered it unequal to resist the strain incident to firing an elongated projectile. This was shown during the previous trial of two other guns, 32-pounders, made also of cast iron, which Mr. Whitworth had too readily consented to rifle, and both of which burst at Shoeburyness. Sir William Armstrong, at a later period, made the attempt to hoop and rifle cast-iron guns, but with no better success.[2] The military authorities appear to have considered that in the instance of Mr. Whitworth the guns had been weakened to too great an extent by the process of rifling, and hence the Secretary at War, somewhat precipitately, imputing to the system what is now admitted to be ascribable to the structural material of the gun, directed the inventor to be informed, that, as the three cast-iron

[1] It is found advisable to employ for penetrating armour-plates, flat-fronted projectiles whose diameter is in excess of the thickness of the plate to be penetrated, thus a ball of 3-inch diameter pierces the plate $2\frac{1}{2}$ inches thick, one of $5\frac{1}{2}$-inch diameter pierces the $4\frac{1}{2}$-inch plate, the 7-inch bolt pierces the $5\frac{1}{2}$ or 6-inch armour-plate, that is, provided the gun is able, like the Whitworth, to give the projectile sufficient rotary velocity.

[2] See *Evidence of the House of Commons' Select Committee on Ordnance*, 1863, 3,228.

guns which he had bored polygonally for the Government up to that period, had all burst at a very early stage, *the resolution had been taken to discontinue experiments with ordnance rifled on his principle*.'

This determination was hasty on the part of the Government, and discouraging as regarded Mr. Whitworth, inasmuch as it was a judgment adverse to the whole 'system' in which he had worked so successfully; and this, too, delivered from the highest constituted authority in such matters. But so far from deterring him from further exertion, it appears to have had the opposite result. Impelled by the most irrepressible of all moral forces, the consciousness of truth ignited by a sense of wrong, the letter from the War Office had the instant effect of arousing all his energies to the vindication and development of the principle which had been so sweepingly denounced. Heretofore he had been but an amateur advising and assisting others by the aid of his own discoveries; but, as stated elsewhere,[1] the effect of General Peel's order was to convert him into a manufacturer of guns.

It is scarcely necessary to repeat, that Mr. Whitworth has never since departed from the 'principle' so summarily rejected five years ago, and *that all the guns made by his firm, with which such surprising results have been obtained, in* 1862, *and since, have been rifled without a trace of variation, on the identical 'principle' condemned by the War Office in* 1858.[2]

[1] See *ante*, Part II. chap. v. p. 167. See also p. 174, 176.

[2] 'The brass howitzers which I rifled for the Government in 1856,

Whatever may have been the *rationale* of the failure, the victory for the moment practically remained with the ship; the flat-headed shot had, doubtless, overcome the iron, but it had as equally overcome the gun.[1] Still confident in the truth of his system, and undeterred by a disappointment incident to the mode of its application, Mr. Whitworth accepted the principle that failures are but the nurses of success; and on the instant of the bursting of the cannon at Portsmouth, he repeated to the Lords of the Admiralty his unshaken conviction in his ability to produce a rifled 68-pounder gun, so strong as to be limited in its charge of powder only by the quantity it could consume, and so powerful as to penetrate armour plates $4\frac{1}{2}$ inches thick, at fighting ranges, with absolute certainty. The only effect, therefore, of the bursting of the gun, in 1858, was to delay for a time the full development of his plan; and being deprived of government cooperation, he determined to manufacture guns of homogeneous metal and to make them so strong as to resist the utmost strain

I could not now improve on.'—See Mr. WHITWORTH'S *Letter to The Times*, March 1, 1860.

[1] The public, however, were disposed to award the victory to the gun. *The Times*, convinced that the same principle by which the Whitworth rifle had triumphed over the ancient musket, would equally enable the new ordnance to supersede the old, said: 'The fact is already accomplished, for only the other day, after the iron-sided target had baffled the powers of ordinary artillery, it occurred to some one to try the capacity of a Government gun rifled by Mr. WHITWORTH. The result was declared in an instant; for the new cannon *slapped her shot through the iron plate as if it had been so much gingerbread!* and ruined the theory of impregnable batteries for some time to come.'—*The Times*, Oct. 22, 1858.

to which they were likely to be subjected when firing rifled projectiles at velocities so high as only to be attainable with full charges of powder.[1] To this task he addressed himself; but more than a year elapsed before his guns were ready and that he found himself in a condition to make the next and crowning trial, which took place against the sides of an iron-plated gunboat in the spring of 1860.

During this long interval he was engaged, as he afterwards explained in the course of a discussion at the Institute of Civil Engineers, not alone in the construction of his large rifled cannon, but in the equally important task of promoting the improvement of the *material* of which they were made. While the attention of Sir William Armstrong was devoted to the development of his mode of construction with coiled and welded iron, Mr. Whitworth uniformly expressed his opinion that a harder and tougher metal must be sought for. He predicted that for heavy artillery the wrought-iron coil would not answer, and that when employed for inner tubes it would prove insufficient, since the difficulty of working it in large masses so as effectually to resist the searching force of the gases engendered during the explosion of gunpowder in the gun, amounts almost to an impossibility. In this conviction he deter-

[1] In measuring the strength and power of endurance of a rifled gun, it is always necessary to take into consideration the charges that are employed. If rifled guns are fired with comparatively small charges, they may be made to last, even if they are really deficient in strength, but in that case, only low velocities are obtained, and the guns cannot fire the shot through armour-plates of the thickness now employed.

mined, as before stated,[1] to use for his great guns the homogeneous metal which had proved successful both in his rifled small-arms and field-pieces, and hence the time spent by him at this important crisis in earnest endeavours to introduce successfully a metal decried at the moment, but whose superiority over welded coil is now admitted by Sir William Armstrong and the superintendent of the Royal Factory, so far as regards its use for the inner tubes of built-up guns.[2]

In the autumn of 1859, the *Committee on Iron Plates and Guns* had made various experiments at Shoeburyness; the object being to test the comparative power of solid rifled projectiles fired against the sides of the 'Trusty,' which (as has been already stated) had stood proof against the guns of Sir William Armstrong in January and September 1859; both these trials had been conducted by the *Committee on Iron Plates and Guns*, and, in both instances, projectiles were used having the flat-front invented by Mr. Whitworth. In the January trial most of the 32-pound bolts, of whatever material, though not absolutely flat-fronted for the entire diameter, had their coned heads truncated in regular gradations till the cone was all but removed; whilst in September, the only bolts from the 80-pound which effected a lodgment were entirely flat-fronted. Thus both experiments bore testimony to the value attached, alike by Sir William Armstrong and by the

[1] See *ante*, Part II. chap. v. p. 177.

[2] See the *Evidence* of Mr. Anderson taken by the *Select Committee of the House of Commons on Ordnance*, May 1863, 1849, and of Sir William Armstrong, 3163, 3508, 3511.

Committee, to the flat-front for projectiles, which Mr. Whitworth was the first to employ with effect against iron plates.

By the latter end of 1859 Mr. Whitworth completed his heavy breech-loading gun of $5\frac{1}{2}$ inch bore, having an inner tube formed of homogeneous metal or mild steel bored out of a hammered ingot. It was calculated to throw solid shot and shell up to 80 lbs. weight. This was the same gun, the performance of which has been already described when it was fired on the sands at Southport in Lancashire, in the February previous, and its precision was found to be such, that three out of four of the shots from it, 'at a range of two miles, would have gone through a target less than one yard high and not more than a foot in width.'[1]

The projectile was peculiar: for in addition to being flat-fronted and made of the same homogeneous metal as the gun, it now exhibited *the tapered rear*,[2] which contributed materially to add to its range and steadiness of flight.

From Southport the gun was taken to the Thames, to be tried against the armour-plate of the 'Trusty,' in presence of the Lords of the Admiralty, in the month of May 1860. It was placed on board the 'Carnation' gun-boat, moored at 200 yards distance from the 'Trusty,' and was served with charges of 12 and 14 lbs. of powder. Although only *four* shots were fired, the power of the new gun and projectile, surpassing all

[1] *Illustrated News*, March 10, 1860.

[2] See *ante*, Part II. chap. v. p. 186.

that had been previously tried, was shown by the clear penetration of every shot through the armour.

Two projectiles entered the ship; and one of them under circumstances so singular as to entitle it to special record. It struck fair on a securing bolt of the armour, and cutting out the portion of the plate around the bolt-head so clean that it still remained on it like a loose ring, the bolt, together with the detached lump of iron, was driven inwards, half way across the deck, carrying with it part of an iron maindeck knee.

The shot itself gave evidence of its correctness of form and temper; by showing but a few shallow cracks on its front, and by being reduced only half an inch in length by the force of the collision. Nothing could more clearly demonstrate that both the form and material had been at last discovered for 'punching' the before impenetrable iron; and as affecting the issue of the conflict between armour-plate and artillery, the Lords of the Admiralty, who were present, attested their conviction by bringing the trial to an end, after the fourth shot. Mr. Whitworth was eager to have the firing continued, but the Duke of Somerset forbade it, under the conviction, as he afterwards said, that, 'one or two more shots would have sunk the "Trusty."'[1] This sudden stoppage was, perhaps, prudent; but it was mainly to be regretted, because it deprived Mr. Whitworth of the opportunity to *penetrate armour-plate underneath the water*, and so to exhibit again what is likely to prove

[1] *Evidence of the House of Commons' Select Committee on Ordnance*, 1863, 5183.

one of the most formidable and peculiar properties of these flat-fronted missiles.

So prodigious was the force with which these resistless missiles were impelled, that the moment of collision between the flat-front and the armour-plate was marked by a flash of lightning-like flame; which is frequently observed on similar occasions. The projectiles, too, when found inside the ship were so hot, that it was some time before they could be touched with impunity.

The *heat* so generated is the product of the destruction of motion in the projectile, by its collision with the iron plate. And conformably to the theory of Dr. MAYER of Heilbronn, and the successful experiments of Mr. JOULE of Manchester in determining the invariable relation between heat and mechanical force,[1] if it were possible to collect accurately the entire of the heat so engendered by the bolt in its flight,—including that lost by friction in the gun and in its passage through the air, as well as the portion absorbed by the iron plate or remaining unexpended in the projectile itself,—the sum of the whole ought to be the precise equivalent of the force with which the projectile was moving; and this, were it practicable to apply it mechanically, should suffice to drive it back into the mouth of the gun, with the same velocity with which it left it.[1] But the origin of the *flame* which is sometimes dis-

[1] J. P. JOULE, *Dynamical Theory of Heat*, *Phil. Mag.*, 1843, p. 263, 347, 435. *Ibid.* 1845, p. 369. Prof. W. THOMPSON, *Dynamical Theory of Heat*, *Phil. Mag.* 1852, p. 11. A brief account of the discoveries of

played is not so readily accounted for. It has been suggested that at the point of contact between the projectile and the target, the heat may be so intense as to raise the air caught between them to incandescence; and that this driven out laterally may display the appearance observed; but some experiments conducted by Buche, in America,[1] render it doubtful whether any amount of heat is capable of making air incandescent. Mr. GROVE explains that although in

DR. MAYER and of Mr. JOULE will be found in the Appendix to Prof. TYNDALL's work on *Heat Considered as a Mode of Motion*, p. 445. See also GROVE's *Correlation of Physical Forces*, p. 25, 62, &c. Sir WILLIAM ARMSTRONG has directed attention to the question, whether the heating of a cannon in action is occasioned, not alone by the contact of flame from the gunpowder, but by some *molecular action amongst the atoms of the metal set in motion by the blow of the explosion*? (See *Report of the Select Committee of the House of Commons on Ordnance*, 1862, Appendix, p. 162.) But this is rendered doubtful by the fact that in recent experiments with gun-cotton, the heat imparted to the metal was considerably less than that communicated during the explosion of gunpowder although the force exerted appears to have been greater.

[1] These experiments are recorded in the report of a committee appointed by the Franklin Institute to enquire into the subject of explosions in steam-boilers; it was published in the *Transactions* and in *Silliman's Journal*, about 1838. On this interesting subject of the incandescence of gases, Prof. WHEATSTONE writes to me as follows:—'It was announced by DESSAIGNES, (*Journal de Physique*, 1811, p. 41), that all bodies, even gases, became luminous by strong and sudden compression. Some time afterwards, M. SAISSY, repeating DESSAIGNES' experiments, arrived at other results; he found that light was produced by compression only in air, oxygen and chlorine, that is, in supporters of combustion; but that every other gas remained non-luminous under violent percussion, even in the greatest darkness. M. THENAUD (*Annales de Chimie*, tom. xliv. p. 181), confirmed SAISSY's results, but gives experiments to prove that even in air, oxygen, &c. the luminous effects depend on the presence of extraneous substances, as they evidently do in the well-known "briquets d'air." Some recent authors (GMELIN, *Handbook of Chemistry*, vol. i. p. 205, consider the matter to be still undecided.'

certain cases heat appears to become partially convertible into light, this is owing to some change in the matter affected by heat; thus gas may be heated to a very high point without producing light, or producing it only in a very slight degree, but the introduction of solid matter, platinum for instance, into the highly heated gas instantly serves to exhibit light.[1] Hence the flame in the instance of the gun may be displayed by the intensely hot particles of metal driven off by the collision[2] as well as by the carbon contained in the particles of steel; and the dust set in motion in the air. Mr. Whitworth observes that, according to his experience, much more light is generated by a *steel* projectile than by a cast-iron one; and Mr. Hulse of Manchester suggests that the carbon contained in the plate and in the highly carbonised projectile, being driven out by the collision, and combining atomically with the atmospheric oxygen, is ignited by the heat generated by concussion. The nature of the phenomenon is, however, obscure.

In the course of the survey to which the 'Trusty' was submitted after this encounter, the oak frame-work was discovered to be so much damaged by the effect of the shot, which burst through the wrought-iron plates,

[1] GROVE'S *Correlation of Physical Forces*, p. 6.

[2] Prof. WHEATSTONE tells me that many years ago, he had frequent opportunities of witnessing the phenomenon of vivid flashes of light which made their appearance, whenever the bullets from PERKINS'S steam gun struck the iron target, and in this instance, it must be observed that the bullets were of *lead*, not iron as in the case of the WHITWORTH and ARMSTRONG projectiles.

that it was found necessary to repair the timber-work before the plates could be renewed. 'These trials,' says Sir Howard Douglas, 'confirmed the vast penetrating power of the flat-fronted hexagonal shot fired from the Whitworth 80-pounder without the slightest *injury to the piece; and completely established their* superiority over those of any other gun or projectile hitherto produced.'[1] The public voice approved the dictum of professional judges. Whether it be or be not the fact, as was stated at the time, that the timbers of the 'Trusty,' though built but a few years before, were already in a state of decay, 'it cannot be doubted,' said *The Saturday Review*, 'that if these new projectiles can pierce wrought-iron plates, no strength of *timber* that can be placed behind can possibly secure the safety of the ship; and therefore,' continues the same authority,' the result of Mr. Whitworth's experiment appears to be, that cannon regains its old superiority over all defences that can be contrived for ships of war.'[2]

Upon that head, Mr. Whitworth himself shortly after recorded his own opinion, in a letter addressed to *The Times* on September 28, 1860:—'There is no doubt,' he says, 'but that ships may be built which are proof against ordinary shot, but my experience leads me to believe that the penetration of armour-plates is a question of firing against them a projectile under the proper combined conditions; which are, that it shall be of the proper *shape, material* and weight,

[1] *Naval Gunnery*, pp. 221, 414.
[2] *Saturday Review*, June 2, 1860.

and having the requisite *velocity*. A flat-fronted projectile of properly hardened material, and weighing less than an ounce, fired from one of my ordinary rifles, will penetrate wrought-iron plates $\frac{6}{10}$ths of an inch thick. Again, plates 4 inches thick have been penetrated by the 80 lb. projectiles, and I have no doubt but that 6-inch plates would be penetrated by heavier projectiles with a more powerful gun. Increased thickness of plate, then, is to be overcome by the increased power of artillery; and the question is, *in which case will the capability of increase sooner reach its limits?*

'Ships which are hampered by the weight of enormous plates are so overburdened that they are unfit to carry a broadside of guns heavy enough to penetrate the armour of vessels plated similarly to themselves. Again, a ship constructed to carry very thick plates cannot be driven at the high *speed* which must hereafter give the superiority in naval warfare. And then there yet remains the consideration of *cost*. It is true that the richest nation can best endure this drain of costly equipments, and therefore cheap warfare would be a disadvantage to us, but it is also true that naval casualties and mishaps must be calculated upon, and it would be bad policy to concentrate too large an outlay upon a single vessel.

'It will be for naval authorities to consider the position in which the larger heavily-plated, yet still vulnerable, ship would be placed, if attacked by several smaller and far swifter vessels, each carrying a few powerful guns, and able to choose its distance for

striking an enemy which presents so large a target. What would be the result of firing flat-fronted shots at her plates *below the water* line? or if their concentrated fire be directed upon the axis of her screw propeller—a mark that might be hit at a considerable distance?

'The plan of warding off shot by protecting armour has been often resorted to, but the means of attack have continually proved the vulnerability of the armour, and driven it out of use. It has to be shown whether this will be the case with our ships of war, and I fully concur in the opinion expressed in your paper, that the best and speediest mode of arriving at a right decision is to give full publicity to the results of properly conducted experiments.'

The belief of Mr. Whitworth, thus impressively stated, seems to rest chiefly on his strong conviction of the power inherent in his flat-fronted projectile, when driven forward at a sufficiently high velocity. But this conclusion was not at once accepted by other eminent practical men. Sir William Armstrong was of opinion, even after the penetration of the 'Trusty,' that *form* was subordinate to *material*, and that no projectile really cuts a hole like a punch, but on the contrary, that it *breaks* an entrance by main force. Besides, he thought it impossible that any missile could act as a punch, and at the same time maintain its cutting edge and shape. As to the latter point, the view of Sir William Armstrong (which does not appear to have been generally participated in by professional observers) has since been rendered more than questionable, by the fact that

flat-headed hexagonal projectiles, made of hard metal to fit the form of rifled cannon, have been taken up, after passing through armour-plates, and found so entirely unaffected in shape as to be capable of being *fired again from the same gun.*

It has also been said as regards penetration, that inasmuch as a flat head must bruise all before it, in order to force open a passage for itself, it in reality so applies itself to the piece detached as practically to create a round head in front of its own flat one. Sir William Armstrong, so lately as November 1862, stated in a letter to *The Times*, that he was prepared to try his 'round-heads against the flat-heads of Mr. Whitworth, and his belief that before long it would be seen that the one shape is as good as the other when the proper material is used.' No trial of this nature, so far as I am aware, has yet established this conclusion; and however theoretically it may be correct, practically the fact has been demonstrated, *that a much greater power of penetration* is possessed by the flat-front, as compared with that of the round-front; experiments in statical punching, conducted by Mr. Fairbairn, having shown that although mere *indentation* on the outward surface is less easily produced by a flat than by a round end, yet as regards *thorough penetration* the position is reversed, and twice the force is required to punch iron with a round head as compared with a flat one.[1]

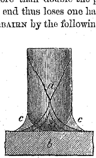
[1] The experiments instituted by Mr. FAIRBAIRN at the request of his colleagues in the *Iron Plate Committee* were two-fold; and the phenomena

The causes which account for the penetrating power of the flat-head have already been adverted to,

were in some respects exceedingly curious. The series of which the result is given above, were undertaken in 1861 for the purpose of investigating the resistance of wrought-iron plates under statical pressure. But another series was commenced the year following, to ascertain the force required to break up projectiles of the three varieties of *cast iron*, *wrought iron*, and *steel*.

Steel, from its tenacity, proved to be above all others possessed of the highest qualities for penetration, as well as for resistance to rupture or change of form under high pressure; and in all essential particulars, wrought iron exhibited its accustomed superiority over cast. Where cast iron was broken into fragments, wrought iron, though distorted, was never disintegrated; the diameter might be distended and the length squeezed into shorter dimensions, but no force was adequate to rupture the material.

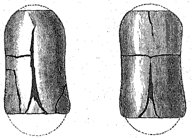
The experiments included both flat-fronted and round-ended shot, and they demonstrated that the *round end* loses more than half its powers of resistance to pressure in the direction of its length; a fact which Mr. FAIRBAIRN accounts for by the hemispherical end concentrating the force on a single point acting through the axis of the cylinder, and thus, in the cast iron, splitting off the sides in every direction. On the other hand, the shot with *flat ends* has the support of the whole base in a vertical direction, and requires more than double the pressure to crush it. The mode in which the round end thus loses one half its power of resistance, is explained by Mr. FAIRBAIRN by the following diagram.



If the rounded end of the cylinder *a* be subjected to pressure against a steel plate *b* of sufficient strength to resist its entrance, the apex *s* forms itself into a cone; which acting as a wedge, splits off the parts *c c* &c., at the angle of least resistance, and then sliding over the sides of

but apart from scientific rationale, mere observers will rest contented with the fact, that whilst in ordinary conditions spherical shot have hitherto failed to penetrate iron, except after previously bruising and rending; and whilst, generally speaking, they glance harmlessly off armour-plates placed at an oblique angle, the Whitworth flat-fronted projectiles were not only the first to penetrate iron plate directly opposed to it,[1] but

the cone, are broken into pieces on the surface of the plate. The following are examples of cast-iron shot with rounded ends thus fractured by Mr. FAIRBAIRN under pressure.



The same effects from *impact* have been discovered in the shot fired against targets at Shoeburyness. In all instances where they were broken to pieces, the central fragment took the form of a cone or core as exhibited at *s* in the diagram above.

The conclusion arrived at by Mr. FAIRBAIRN as to the proper *form* for a projectile intended to penetrate iron, is, that as flattened shot are stronger than round or oval, the form should be a *cylinder with both ends flat*, and the material should be the one least capable of changing forms whilst yielding up its entire *vis viva* to the plate struck; so long as 'adamant' is unattainable, *hardened steel* is the nearest substitute, sufficiently tenacious not to break into pieces, and sufficiently hard to resist powerful compression, nor will the former high price of steel be any longer an obstacle, since instead of 40*l.* or 50*l.* a ton, homogeneous iron shot in any quantity may now be obtained at about 8*l.* or 9*l.* a ton.

[1] Sir WILLIAM ARMSTRONG, at a meeting of the Institution of Civil Engineers, in 1860, questioned the accuracy of the statement, that no

that of them alone, it may be stated, as was asserted by Mr. Whitworth in a letter to the Lords of the Admiralty in October 1861, that they 'never, in any trial, had struck 4-inch iron-plate without passing through it.'

As regards the paramount question of the capacity of iron for resistance, when confronted with the penetrating power of artillery, one reassuring conviction survived even the phenomena of the encounter with solid flat-fronted projectiles. Although the metal had been forced to yield to the attacks of *solid shot*, confidence remained undisturbed in the ability of armour-plating to protect the crew from destruction by preventing the entrance and explosion of *shells*.[1]

shot from one of his guns had pierced iron plate four inches thick; but although it appeared that on one occasion, on firing against wrought iron plates four inches thick, two of the shot traversed both iron and timber — that was done at a very short range, and *with flat-ended shot such as* Mr. WHITWORTH *had previously used*, and, up to that time, Sir W. ARMSTRONG admitted that no gun of his own construction had satisfied the conditions of thoroughly and completely punching through thick wrought-iron plates.—*Minutes of Proceedings of the Institution of Civil Engineers on the Construction of Artillery*, pp. 130, 133.

[1] Even so late as January 1862, the conviction was unshaken in the minds of high naval authorities, 'that round balls are only valuable against plated ships, within 600 yards; and that *shells are of little or no use* against them.' See the lecture of Commander R. A. E. SCOTT, R. N. January 10, 1862, *Journ. Roy. United Service Institution*, p. 17.

CHAPTER IV.

THE WHITWORTH SHELLS PENETRATE ARMOUR-PLATE.

FRANCE was not an inert spectator of what was passing with regard to rifled artillery, and its conflict with armour-plate in England; and about the same time that Mr. Whitworth was demonstrating the insufficiency of the latter, a French 6⅝-inch rifled gun, with a charge of 27 lbs. of powder, drove a 99 lb. bolt through a target representing the side of the 'Warrior' from a distance of 1,093 yards.[1] But besides the fact that iron-plate, though unequal to resist the shock of solid flat-fronted shot, was found strong enough to 'keep out the shells,' there was yet another consideration which served to qualify the feeling excited by the unexpected performance of the new artillery. The aperture left wherever the flat-fronted projectile had cleft a way for itself through the iron, was so clean and symmetrical as to lead to the expectation that it might be possible to plug it in action. Sir William Armstrong, whose maturer experience had led

[1] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1863, No. 4610. It is added that the French, satisfied of the vulnerability of iron-clad vessels, have since laid down no more.

him to modify previous opinions as to the penetrating power of projectiles,[1] although impressed with the faculty exhibited by the flat-headed one to punch the plate, thought it 'probable that no great damage would be inflicted on iron ships, except by using projectiles of such magnitude and weight as would *crush in the side of a ship instead of merely punching holes in it*.'[2] But in order to propel long and heavy bolts with high velocity, such greatly increased charges of powder are required as endanger the gun, owing to the excess of the strain, unless it be fortified by proportional additions to its strength and consequently to its weight; and hence Sir William reluctantly came to the conclusion that rifled guns are not the best adapted for sea

[1] In May 1859, Sir WILLIAM ARMSTRONG, in explaining the effect of shell from his own gun upon ships built of timber, gave a decided preference to the small over the large hole made in penetrating the side. 'So far as shot is concerned,' he said, 'there may be some reason in the objection; but as regards the shell, *the small hole is the very thing wanted*. The shell is caused to explode at the instant of passing through the timber, and the smaller the hole made by it, the more confined will be the explosion, and the greater the shattering produced.' *Speech at Newcastle*, May 10, 1859.

[2] *Minutes of Proceedings of the Institution of Civil Engineers on National Defences*, April 23, 1861, p. 86. Sir WILLIAM ARMSTRONG, in 1863, thus explained the more restricted meaning which he wished to be attached to his words in 1861. He was asked in the *House of Commons' Committee on Ordnance*, 'You have stated, have you not, that the bruises upon armour-plates produced by large shot were worse than holes in those plates produced by small shot?' To which he replied, 'No, I think not. I said that the projectile of a large-bore gun would, in piercing the plate, effect a greater amount of damage than the projectile of a small-bore gun. A large projectile has the disadvantage in penetrating power, but the advantage in destructive effect.' (*Evidence*, &c. 3942.) But this hardly meets the question previously raised as between *bruising* with a smooth-bore and *penetrating* with a rifled gun.

service, since the weight, which appeared to him indispensable, would so far exceed what was held to be manageable in the Navy that he 'did not see what alternative we have, except to make the gun a smooth bore.' [1]

The proposition was startling, involving no less than a retreat from the advanced position to which science had led the way, and a return to the mere display of rude force, cumbersome cannon, ponderous missiles, shortened range, high trajectory, erratic flight, and increased quantities of gunpowder. It was the stone

[1] *Journal of the Royal United Service Institution*, May 19, 1862, p. 151. Within less than four months from the time when Sir William Armstrong gave this strong expression of opinion, as to the greater damage done by a heavy smooth-bore, Mr. Whitworth from a rifled gun fired a 129-lb. shot which caused an opening in the 'Warrior' target such as *The Times* described to be 'not a hole but a *smash*; so that in the case of an actual vessel, such a shot striking on the water-line would have occasioned a leak which nothing could stop.' (*Times*, September 26, 1862.) The occasion on which the occurrence alluded to by *The Times* took place will be found described in Part III. chap. iv. p. 291. There is some difficulty in reconciling the opinion thus expressed by Sir William Armstrong in May 1862, as to the superiority of crushing in the side of a ship by shot from a smooth-bore, with the following passage in favour of penetration by a rifled gun, as contained in his evidence before the House of Commons' Committee in May 1863:—'I do not see how you can produce with steel round shot an effect comparable to the effect which can be obtained with cylindrical rifled shot. With respect to employing steel spherical shell, capable of penetrating iron plates, I consider it out of the question. It is only by means of the elongated form of the projectile that we can construct a steel shell capable of piercing an iron plate, and it is due to the principle of rifling that the elongated form can be adopted. In every point of view, therefore, I consider that rifled ordnance, both for field purposes and for battering guns, is greatly superior to smooth-bored ordnance. I feel perfectly satisfied, that whenever smooth-bored ordnance are brought into conflict with rifled ordnance, whether in the field, or at sea, or in siege operations, the former will invariably succumb.' *Evidence*, 3168, p. 138.

of the ancient catapult, transferred to a new agent of propulsion.[1] 'Stranger as I am to the art of destruction,' says the great historian of the Lower Empire, in describing the ponderous cannon with which Mahomet II. vainly attempted to breach the walls of Constantinople, 'I can discern that the modern improvements of artillery prefer the number of pieces to the weight of metal, and the quickness of fire to the consequences of a single explosion.'[2] The disappointment would be signal were the artillerists of England in the nineteenth century to contemplate a return to the processes tried in vain by the founders of Adrianople in 1453, or to imitate the clumsy device by which 400 years later the Turks sought to fortify the Dardanelles against advances of Russia.

The reasons alleged to justify this sudden change of opinion were not, however, confined to the single consideration of apprehended increase in the *weight of the gun.* It was argued that a greater force, although one more slowly exerted, is required to give impulse to an elongated projectile in its exit from a rifled gun, than is necessary to impart its first rapid motion to a spherical shot leaving an old smooth-bore cannon; and therefore that the *initial velocity* of the latter was proportionally greater, although the merit of a more prolonged range belonged incontestably to the former. Hence, as actions at sea are conducted chiefly at close quarters, unlike battles on land, which are often unavoid-

[1] Paper by R. Mallet, Esq., on *Artillery, Pract. Mechan. Journ.* p. 475.
[2] Gibbon, *Decline and Fall of the Roman Empire*, chap. lxviii.

ably carried on at greater distances, high *initial velocity* with heavy shot was maintained by some to be the chief essential for a naval gun, in conformity with the rising belief that bruising and smashing are more destructive than thorough penetration. On the same ground it was asserted that if mere bulk could be obtained in a projectile hurled at a high velocity, the quality of the *material* would be a matter of indifference, and notwithstanding that Mr. Whitworth had demonstrated that however dense and costly the *material*, a special adaptation of *form* is essential for penetration, still as penetration itself was likely to be little appreciated, unless accompanied with great 'smashing effect,' form itself was now threatened with the loss of repute.

But admitting fully the paramount importance of initial velocity, is there not precipitancy at least, if not misapprehension, in assuming that the old smooth-bore firing a spherical ball is capable of exhibiting it in a higher degree than a rifled cannon? The contrary has been shown by actual experiment;[1] and the fact is established, that although a cylindrical projectile *when considerably elongated* is insuscep-

[1] In the course of a discussion on *The Construction of Artillery* at the Institution of Civil Engineers in 1860, it was stated by Mr. E. A. Cowper that in the Whitworth gun, in some cases, the projectiles fitted the bore so closely, that upon putting a finger upon the touch-hole, and pushing the projectile down the gun, it would spring back of itself on being released. (*Proceedings*, &c. 1816, p. 87.) This extreme accuracy, however, is not necessary or desirable. 'It was at one time imagined,' said the Duke of Somerset to the *House of Commons' Committee* of 1863, 'that a smooth-bored gun must have greater velocity than a rifled one; but this is an error which we have corrected with increased experience.' *Evidence*, &c. 5134.

tible of initial velocity in so high degree as a round shot or a bolt of the same weight only slightly prolonged, yet one of the latter, or even a rifled sphere, may nevertheless be fired from a rifled piece with higher initial velocity than the spherical shot from a smooth-bore. For example, the average initial velocity of a spherical 68-lb. shot, thrown from a smooth-bore with a charge of one quarter its weight of powder, is 1,600 ft. in a second, and this it very speedily loses; on the other hand, with a shot of the same spherical form, but rifled to fit the gun, Mr. Whitworth obtains an initial velocity of 2,200 ft. in a second, being greater than the spherical shot from the smooth-bore in the proportion of 11 to 8. When the projectile was slightly elongated so as to render its length equal to once and a half its diameter, being in fact a short cylinder, its initial velocity was reduced to 1,900 feet per second, but even this was still 300 feet per second greater than that of the spherical shot from the smooth-bore.[1] The reason of this increase of initial velocity in the rifled spherical shot is that it fits the bore of the gun, so that the gases generated during explosion, which partially escape in the instance of the spherical shot from a smooth-bore, exert their whole pressure in propelling the rifled one through the barrel. This increase of velocity would not,

[1] An exposition of the comparative initial velocity of a spherical to an elongated projectile, will be found in Mr. WHITWORTH's reply to question 2350, in his *Evidence* before the *House of Commons' Committee on Ordnance*, 1863, pp. 102, 106. Sir WILLIAM ARMSTRONG (*Ibid.* 3167) says the initial velocity with a rifled gun is quite equal to that with a smooth-bore, the weight of projectile and charge being the same in both cases.

however, be so great in the Armstrong gun, because there, a larger part of force is expended in compressing the leaden surface of the projectile into the many grooves along which it has to pass. This force has been estimated by Sir William Armstrong at a pressure of *several tons* in the case of a 12-lb. shot; whereas in the Whitworth gun, the shot being already rifled and fitted to the bore, *it may be started and drawn through the barrel with a silken thread.*

If high initial velocity be the only desideratum, Mr. Whitworth's experiments proved that it may be obtained more effectually with a suitably rifled gun, firing *spherical* or *short elongated projectiles.* But in that case the bore of the gun must be large, to give the projectile sufficient weight, and as large charges of powder must be used, the advantages which attend the 'reduced bore' in regard to range, precision, and economy of powder would have to be sacrificed.

But then it must be borne in mind that these latter conditions are not consistent with the advantages relied on in ordinary rifle and cannon-practice, where the length of the projectile varies; being *two*, or *two and a half times* the diameter in the Armstrong system, and *three times* (or in special cases more) in that of Mr. Whitworth, according to the different purposes to which the projectiles are applied. In firing these, the initial velocity is no doubt lower than that of the smooth-bore, the charge of powder being reduced, to avoid excessive strain on the piece. Hence it follows that *long rifled projectiles*, which alone are effective for the faculty at

once of sustained velocity, flight, precision, and penetrative power at great distances, cannot be fired at very high initial velocities, without such large charges as would endanger the gun, unless it be fortified with such additional weight of metal as to render it unwieldy and unmanageable.

If, however, a compromise were to be made, it would be found that very high initial velocities are unnecessary; as the rifled projectile maintains its speed for a comparatively long flight, diminishing, it is true, constantly, but by very minute degrees. For example, the velocity of a spherical shot, fired from a smooth-bore with an initial velocity of 1,600 feet per second, becomes at 400 or 500 yards about equal to that of the rifled shot of equal weight and three diameters long, fired with an initial velocity of 1,200 or 1,300 feet per second. If, therefore, for operating against iron-plate there be given to the rifled projectile fired with that comparatively low initial velocity a proper form, and it be made of a material suited to the work which it has to perform, more especially if it be made to carry its bursting charge as a shell, the superiority of the rifled over the spherical shot for all purposes, including penetration, becomes incontestable. This, however, was strenuously denied no later than the spring of 1862, and a return to the smooth-bore and spherical shot was strongly advocated by their old supporters, and accepted, though probably with reluctance, by the official advisers of the War Office, because, for purposes of penetration, they had at that time nothing better to offer.

It was somewhat discouraging, too, to find the expediency of such a surrender indicated as probable by Her Majesty's Ministers in Parliament. The Duke of Somerset, in the House of Peers, stated on April 3, 1862, 'I used to think that no plates could resist rifled guns, but I have changed that opinion. We have found that they are not so effective as we supposed; and that we must arm our ships with heavy smoothbore guns, the velocity of which at 200 yards is much greater.' This opinion was about the same time repeated by the Secretary of the Admiralty, in the House of Commons; but little more than twelve months elapsed before farther experience corrected this precipitate conclusion, and in July, 1863, the Duke of Somerset stated to the *House of Commons' Committee on Ordnance Expenditure*, that what he spoke was under a misapprehension.[1]

On the first indication of this threatened abandonment of progress, and a return to the antiquated system from

[1] 5216. *Colonel Dunne.*—Is your Grace aware, that in all these kinds of guns the initial velocity of the spherical shot is greater than in any rifled gun?

Duke of Somerset.—No. I do not admit that. I do not think it has been proved.

5217. *Colonel Dunne.*—But it has been asserted here?

Duke of Somerset.—It has been asserted here,—and what is worse, I asserted it in the House of Lords; but I was under a misapprehension. We have not arrived at the knowledge that we shall in a short time have with respect to these guns.

5218. *Colonel Dunne.*—The whole science of gunnery is in a transition state, you think?

Duke of Somerset.—Yes; and so much so, that when I was this year asked what gun I approved of for the navy, I was obliged to say that I really did not know.

which for so many years it had been the aim of men of science to discover a means of escape, no one seems to have felt more keenly than Mr. Whitworth the sense of humiliation which would be involved in such a retrogressive movement towards the pre-Raffaelism of artillery. A letter to *The Times* in April 1861, besides containing his protest against a course so detrimental to the national interest and so derogatory to the honour of science, is further remarkable for the unfaltering assurance of his confidence, not only to realise to the fullest extent all the exigency demanded, as to the destruction of armour-plating by solid shot, but to achieve that which by all had been regarded as impracticable, namely, to send explosive *shells* through the iron sides of ships of war, heretofore, in this respect at least, believed to be invulnerable.

To the Editor of The Times.

SIR,—The experience acquired from recent naval engagements shows that, as regards ships of war, the means of defence have progressed in advance of the means of attack at present employed. The possession of an iron-plated navy is confessedly proved to be a necessity; I venture to add that it is equally a necessity to arm that navy with artillery which iron-cased ships cannot set at defiance.

It has been said that this can only be done by using smooth-bore guns of large size, throwing shot of great weight, which will crush in the side of the iron ships,

and this would seem to have become the conviction in some official quarters. But, whatever may have been the result of comparisons made by others between rifled guns and smooth-bores, those made by me have led to a very different conclusion.

It is difficult to believe that the experience of rifled guns in our service has led to the advocacy of so retrograde a step as the readoption of the smooth-bore in preference to the rifled guns, which, with elongated projectiles, made of the proper shape and material, and having the requisite velocity, will always prove incomparably more effective. The object to be effected is to force an entrance through the ship's wrought-iron side. To attempt to do this by firing *cast-iron* projectiles, in the vain hope of making the weaker material overcome the stronger, is manifestly absurd. No one would use a cast-iron punch to perforate a wrought-iron plate, nor would the head of the punch be made spherical. Wrought-iron should not be attacked with a metal inferior or only equal to itself, but with a metal superior in strength and hardness, formed into a shape suited for penetration, and propelled with the requisite velocity. To have recourse to huge round-shot to smash in the ship's sides is like employing brute force and neglecting the aids which science and mechanical experience have placed at their disposal.

If by the use of properly adapted projectiles we can make the iron-sided ship vulnerable without employing guns of inordinately increased size, we shall in an efficient manner restore to attack its supremacy over

defence. *That this may be done I confidently assert, and my experiments justify me in stating that not only solid, but also hollow flat-fronted projectiles, capable of being charged with explosive or combustible compounds, may be fired through the new iron-plated vessels at much greater ranges than those at which the recent action was fought between the American vessels.*

When my rifled $5\frac{1}{2}$-inch-bore gun was officially tried against the armour-plates of the 'Trusty' at the Nore (see *The Times* of May 28, 1860), every shot that hit the plates penetrated through them, and the shots that were picked up between the decks, after passing through both the iron plate and its timber backing, were found so little injured in the rear part that *I have no doubt of being able to fire from my 7-inch guns hollow projectiles that will penetrate plates thicker than those of the 'Trusty.'*

Again, there is a mode of attacking the partially plated hull of the iron ship which ought not to be lost sight of. Official experiments made on board the 'Excellent' have proved that my flat-fronted projectiles, after being fired through as much as 30 ft. of water, retained great penetrating power. Iron ships are usually plated only to a limited depth, and flat-fronted projectiles, as they will go through water, are capable of inflicting great injury, both by damaging the propeller and by *piercing the side of the ship below the water-line.*

These are points bearing so directly upon the question

of what will be required henceforth in naval warfare, that I think they call for careful consideration.

I remain, Sir,

Yours most obediently,

JOSEPH WHITWORTH.

London, Fenton's Hotel: April 4, 1861.

Near the close of the session of 1861 a motion was made in the House of Commons by Mr. Hussey Vivian, M.P., for the appointment of a Committee to enquire into the expediency of superseding the Enfield rifle and providing the British army with a more efficient weapon. The motion was withdrawn on the assurance given by the Prime Minister, that the whole subject should have the prompt attention of Her Majesty's Government. Conformably with this promise, Lord Palmerston a few months later, accompanied by the Secretary of State for War, went to Shoeburyness, and witnessed in person the practice with the Whitworth guns.

Amongst other results of that visit, was an order to Mr. Whitworth to prepare a gun with a bore of 7 inches, and calculated for firing shot or shell weighing 150 pounds. Not having at that time machinery at his own works at Manchester calculated for the production of ordnance of so large a calibre, Sir George Cornewall Lewis gave instructions that the gun should be made at Woolwich, 'according to Mr. Whitworth's principles and under his *directions.*' In the drawing which he prepared, Mr. Whitworth, took the precaution of increasing the weight of the gun from four tons, the weight of

the then seven-inch service rifled gun, to seven and a half tons; and of distributing the metal in uniform layers; that is, in hoops of a nearly equal thickness. Some of the details of construction were modified to suit the resources and processes of manufacture pursued at Woolwich, but the principle and the original outlines and essential features of the design[1] were preserved; and the gun, a muzzle-loader, was eventually made by Mr.

[1] The circumstances connected with the making of this gun, gave rise to a disagreeable controversy, the particulars of which were investigated by the *Committee of the House of Commons on Ordnance*, April 1863. From the incident of the gun being made at Woolwich by an officer subordinate in rank to Sir WILLIAM ARMSTRONG, and out of a material of which he claims the application, it was alleged that whilst the rifling was on the system peculiar to Mr. WHITWORTH, the gun was '*an Armstrong gun.*' The facts as above stated were relied on by Mr. WHITWORTH in asserting, on the contrary, that it had in reality been made according to his own drawings; in which the only changes admitted were the result of conferences in which the modifications proposed by Mr. ANDERSON were discussed and mutually agreed on between that gentleman and Mr. HULSE, the partner of Mr. WHITWORTH, and were submitted to and finally approved by Mr. WHITWORTH himself. The *Ordnance Select Committee* (who are the official advisers of the War Department) had unhappily committed themselves in this matter by an opinion formed on imperfect knowledge of the facts, and expressed in terms highly offensive to Mr. WHITWORTH. The opportune sitting of the House of Commons' Committee afforded facilities for ascertaining the facts, and after the production of the complete correspondence, and the disclosure of the whole circumstances by the examination of all the parties concerned, the statement of Mr. WHITWORTH was confirmed, and it was shown that, notwithstanding the nature of the metal out of which the gun was unavoidably manufactured, which rendered modifications in details indispensable, it was made according to his own design, and as nearly conformable to it as the circumstances admitted. Mr. WHITWORTH's apprehensions of the inability of the welded coil to sustain the strain about to be applied to it were unfortunately justified by the result; the gun after a very short use exhibiting a flaw such as has rendered it expedient to fire it with reduced charges of powder.

Anderson as nearly as was practicable in conformity with Mr. Whitworth's drawing. The first trials with it took place at Shoeburyness, in September 1862, in order to test the power of flat-fronted shells to penetrate armour-plate. As shells of every description theretofore tried had uniformly failed, being either broken into fragments by the concussion, or else bursting on the outside of the plate, without any other effect than that of discolouring it by the explosion, expectation, notwithstanding the quiet confidence manifested by Mr. Whitworth, was diffident as to the chances of his success.

And here it is necessary to advert to one curious peculiarity of the Whitworth shells—*that they explode without a fuse.* In all others the fuse and its proper construction are matters of the deepest solicitude, as upon its ignition and the nice calculation of the time to be occupied in its combustion, depends the bursting of the missile at the precise moment when it should reach its destination. Mr. Whitworth, however, discovered during the experiments with his flat-fronted shell that when striking with high velocity it suddenly encounters the iron plate, heat is generated to such a degree as to explode the bursting charge within.

The cause of this evolution of heat has been already explained;[1] it is generated by the disruption and displacement of atoms in the metal occasioned by the percussion between the projectile and the iron plate; and one of the difficulties with which Mr. Whit-

[1] See *ante*, Part III. chap. iii. p. 263. See also Professor TYNDALL'S *Lectures on Heat considered as a Mode of Motion*, pp. 7, 42.

worth had to contend was the tendency of the shell to explode on the instant of striking the plate, and before it had yet succeeded in passing through it; wasting its force unavailingly outside, instead of bursting after effecting an entrance within. To counteract this, he adopted the simple and successful expedient of enveloping the gunpowder in one or more plies of flannel, before enclosing it in the chamber of the shell; thus interposing a slow conductor between it and the heated metal, so as to delay the explosion till the shell should have passed fairly within the ship's side.

Externally, his flat-fronted shell differs in no perceptible degree from his flat-fronted solid shot of the same form; the gunpowder, in a flannel envelope, *is placed in a suitable cavity in the shell-case*, and

THE WHITWORTH SHELL.

made secure by firmly screwing on one end. The vast importance of this novel construction will impress itself nowhere so strongly as on the minds of those familiar with the appalling circumstances attendant on the

accidental explosion of shells on ship-board; the result of incautious handling or imperfect stowage, by which the fuses have become ignited.[1] The Whitworth, exempt from this liability, may be piled like solid shot, or even let fall upon the deck, with no risk of explosion.

The first experiments with these newly invented shells extended over two days, beginning on September 16, and being renewed on the 25th. On the first day the trials were made from a range of 200 yards, which was afterwards increased to 600; and this on the second day was extended to 800 yards.

On the first day, immediately after the trial of the Horsfall gun (to which reference has been made in a former place[2]), the Whitworth 12-pounder was fired from 200 yards against a target formed of 12 inches of oak covered by 2 inches of iron, a thickness which the failure of all previous attempts with shells had led other European governments as well as our own to regard as a sufficient protection against them. The illusion was effectually dissipated on this memorable occasion; as the first shell passed completely through the target, and buried itself deep in the sand hill behind. When dug up it was found unburst, a result attributed to the too great thickness of the flannel bag in which the gunpowder was enclosed. One ply was therefore removed in the next shell, which like the former one, penetrated the armour-plate

[1] See the directions given by Sir HOWARD DOUGLAS for the stowage of shells to prevent accidental ignition.—*Naval Gunnery*, sect. viii. p. 289, &c.

[2] See *ante*, Part II. chap. i. p. 93.

and the backing, but exploded in the rear of both. *No hollow projectile had ever before passed unbroken through more than one inch of wrought iron.* The dreaded problem was therefore solved, and shell for the first time showed its ability to affect a lodgement within the mail defences of a ship.

For the practical purposes of war, the deduction from the grave fact thus established by this small piece of ordnance, as to the vulnerability of iron of ordinary thickness, was chiefly important as putting an end to the imagined safety of gun-boats in shallows, and of iron-clad vessels intended to navigate inland waters, the draft of which renders them incapable of carrying heavy armour. Thenceforth it became evident that land forces moving with common field-guns along coasts and river banks, would be competent to cope with such assailants.

But this result, unforeseen and disconcerting as it was, was surpassed by what followed. The scene of action was transferred to another target, in order to test the encounter between stronger armour and shell of larger size from a gun of greater calibre. A Whitworth 70-pounder (but weighing only four tons) was next tried against a box-target seven feet in length by four feet broad, made to represent a section of the side and interior of a ship. The front was of wrought-iron *four* inches in thickness covering nine inches of oak, and three feet behind it the back consisted of four inches of solid timber faced with two inches of iron plate. The shell, which weighed

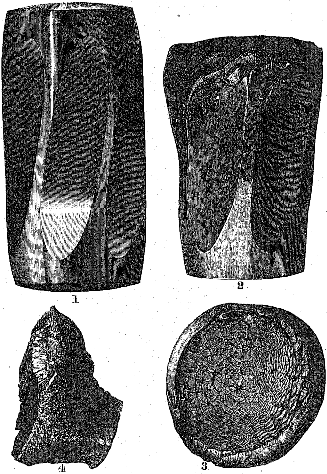
upwards of 68 lbs., with a bursting charge of $2\frac{1}{2}$ lbs. of powder, was fired as before at 200 yards. It passed unbroken through the armour and teak, exploded against the plate which formed the back of the target; and bursting into large pieces, it drove out the sides, shattering the timber and iron of the box-target to fragments.

This startling result, it is to be observed, was obtained by a gun of no unusual dimensions, being lighter than an ordinary 68-pounder, and with a charge only one-sixth the weight of the projectile.

But the question still remained whether *five* inches of iron would suffice when *four* inches had failed, and whether safety would be insured by increasing the distance beyond *two hundred* yards. This momentous issue was tried a few days later [1] with the same result, but with a still more powerful gun, the Whitworth with a seven-inch bore made at Woolwich being now ready for trial. It was about twelve feet long, and of the calibre of seven inches.

The target on this occasion was a new one, the same against which the Horsfall gun had just before been fired, twenty-one feet in length and fifteen feet high, representing the 'Warrior's' side. Behind $4\frac{1}{2}$ inches of armour-plate, there were eighteen inches of teak lined with iron $\frac{5}{8}$ths of an inch thick, the whole supported by upright angle-irons at intervals of a foot and a half. The gun was laid at the distance of 600 yards, and after a few shots, to get the range, the grand trial began, the particulars

[1] September 25, 1862.



WHITWORTH FLAT-FRONTED SOLID SHOT, 129 LBS., FIRED AGAINST THE 'WARRIOR' TARGET, SEPT. 25, 1862.

1. Shot before being fired.
2. *After passing through* $4\frac{1}{2}$ *in. of iron plate.*
3. Front after the collision.
4. Piece of iron forced out of the iron plate by the blow.

of which cannot be better described than in the words of an eye-witness in communication with the *Times*:—'The first experimental shot, a solid hexagon weighing 129 lbs., was fired with a charge of 23 lbs. of powder, the piece being laid at half a degree of elevation. It struck the left centre *within an inch of the white spot at which it was aimed*, and at the instant of the tremendous concussion of the metals, a bright sheet of flame was emitted, almost as if a gun had been fired from the target in reply.[1] The shot passed completely through the armour-plate, shattering the teak beyond into minute splinters. It struck full upon one of the massive vertical angle-irons, which it tore in half as if it had been paper, driving the screw-bolts and rivets in all directions. 'The shot, however, did not pass *through* the target, but remained buried in the teak with its flat head resting against the broken angle-iron.[2] But the fracture it made was much worse than a mere penetration. It was a *smash*, not a hole; and the inner skin of the ship was bulged and torn widely in many places, so that in the case of an actual vessel, such a shot striking on the water-line would have made a leak that nothing could

[1] See an account of this phenomenon, *ante*, Part III. chap. iii. p. 263.

[2] Projectiles of homogeneous iron, as used by Mr. Whitworth, seldom lose their form in passing through iron plate. They are frequently so unaltered as to be capable of being forced again from the same gun. On this occasion the front was flattened by the collision, the effect of which is exhibited in the engraving which accompanies this page, showing the figure of the 129th shot before being fired, its appearance afterwards, when it was shortened, or, as it is technically called, 'set up,' 2·15 inches by the blow; together with a view of the piece driven out of the solid armour-plate in forcing a passage through.

stop. 'As regards the effect of these flat-fronted shot on iron ships, this experiment was conclusive. Such a missile against a wooden ship would have gone through both sides, making a clean hole and doing little damage; but the iron, without protecting, offered only sufficient resistance to make the fracture, if below the water-line, an irremediable mischief. 'The next experiment was with a *shell* loaded with 3 lbs. 8 oz. of powder. The total weight of this projectile was 131 lbs., and it was fired with a charge of 25 lbs. of powder at the same range and elevation as the shot. The effect astounded everyone. The previous *solid shot* at 600 yards was, for Whitworth, nothing very extraordinary; but to get a *shell* through the target at the same range was regarded as almost an impossibility. Yet the shell went completely through everything, bursting apparently when it encountered the last resistance of the inner skin, which the explosion blew completely away; setting on fire for a moment the timber at the back, and sending the bits of shell onward and over what, had it been the "Warrior" herself, would have been her main-deck; and, therefore, right into the midst of her crew.' [1]

[1] *The Times*, Sept. 26, 1862. As an inference from the events of the day, *The Times* says, 'In our humble judgment, we think that in the end guns *must* carry the day; for while there is no limit to the size and weight of the ordnance which fortifications or even ships can carry, there is a most decided limit which sea-going frigates can support—a limit which we have fully reached, if indeed we have not overpassed it, in the $5\frac{1}{2}$-inch armour vessels now building. . . . . The "Warrior," with its $4\frac{1}{2}$ inches of iron and eighteen inches of teak, has been tried and remained invulnerable, till a special antagonist—the 150-pounder smooth bore

On the same occasion on which these occurrences took place, the trials were made of the great Horsfall gun, which have been described in a previous chapter.[1] At the close of the day's proceedings, one round of solid cast-iron shot was fired from a 68-pounder at 200 yards, and the engraving which accompanies this[2] exhibits the comparative damage inflicted by this antiquated piece of ordnance as compared with the crushing force of the Mersey forged gun, and the swift and penetrative power of the Whitworth. The shallow indentation at the left-hand corner below, shows the feeble effects of the smooth-bore 68-pounder; — the cleanly-punched holes to right and left of the central plate are those produced by the flat-fronted projectiles from the Whitworth rifled gun; — whilst the hideous gashes between, mark the destructive effects

muzzle-loader of Sir WILLIAM ARMSTRONG — was brought against it (*but the gun itself was destroyed* by the heavy charges used to enable it to destroy the target). Since then, the Horsfall 300-pounder has sent its shot through a similar target, as easily as if it was so much canvas. The Whitworth 12-pounder has sent *shells* through iron, which until now no shells had affected; and his 70-pounder, shells through oak and iron each *four* inches thick; and to crown all, yesterday his 120-pounder sent shells even through the "Warrior" itself! . . . . As a general principle, however, our own ships are invulnerable by the guns of other navies: the French *canon rayé* has no more effect upon them than the Armstrong; whilst the American Dahlgren throws only spherical shell, which are useless against iron sides. But we know from yesterday's experience, that a gun *can* be made to pierce an iron ship; and the point now is, which is the best for that purpose? The Armstrong is out of the question. The enormous range, great accuracy, and terribly destructive effects of its shell, must, till a better gun in these respects is invented, always make it one of the main defences of our fleets and forts, and above all, our best gun for land service, but against iron ships it is simply useless.'

[1] See Part II. chap. i. p. 94. [2] See *Frontispiece*.

of the ponderous spherical balls from the monster Mersey gun, by which also the angle at the top of the target to the left was torn away.

Looking back to the events of the day, the great merit of the Whitworth shell consists in its simplicity, and the suitability of its shape to the work it has to do; and in the successful treatment of the homogeneous metal of which the shell is made, so as to render it in this new form capable of penetrating wrought iron without breaking up on the first concussion. Like the shot, the shell drove before it a contorted lump of iron, 'smashed' out of the solid plate, and weighing upwards of 30 lbs.

Another remarkable feature was the comparatively small quantity of powder which produced such prodigious effects. When the Armstrong gun penetrated the 'Warrior' target in the spring of 1862, the charge of 50 lbs. was so great as to cause the destruction of the gun; the Horsfall consumed 70 lbs. of powder, and it came to be regarded as a settled matter that something between 40 lbs. and 50 lbs. of powder were required to send a shot through four inches of iron at 200 yards. The Whitworth bolt penetrated at 600 yards with a charge of no more than 25 lbs., a result to which the flat-front was mainly conducive. 'Mr. Whitworth,' says a writer in *The Saturday Review*, 'has thus removed the ultimate limit of artillery power to double its former range; for all the serious difficulties, whether in the original construction or the actual use of ordnance, resolve themselves into the one problem,

of making a cannon heavy enough, or rather, making it strong enough, to bear the explosion of a given quantity of powder.'[1]

Opinion was still divided as to the consequences of the damage so inflicted, notwithstanding the confident belief expressed by *The Times*, that the aperture opened by the passage of the shot through the target would have caused an irreparable breach in a vessel if struck on the water-line. Whilst the majority participated in that conviction, there were others who entertained the impression that a hole so nearly symmetrical might still be rendered water-tight by appropriate plugs. But even admitting the practicability of so dealing with a single injury of this formidable character, and with ordinary facilities for repairing it, it still remains a grave question whether in the heat and excitement of action such expedients could be applied with sufficient speed and efficiency to the number of such shot holes as might be produced by a single broadside. The Americans, who are by no means indifferent spectators of what is passing in the arsenals of England, have adopted the latter view; and their press, echoing the opinion of their naval authorities, says, 'Great indentations and extensive fractures are not such fatal disasters. A mere chasm in a wooden wall

[1] *Saturday Review*, Oct. 4, 1862. Mr. Longridge, in a Paper *On the Construction of Artillery*, read before the Institution of Civil Engineers in 1860, stated with perfect accuracy that 'the first point in the science of Gunnery, and that which limits its future, is the construction of a gun of sufficient strength to curb and govern the utmost force of the explosive compound which may be used in it—in other words, a gun which gunpowder cannot burst,' p. 4.

would not have put an old frigate *hors de combat*. But when a broadside of shells, charged with explosive materials or molten metal, gets into the bowels of a ship, through never such small and neat holes in her armour, affairs begin to be serious. This is not the work of large bores and low charges. It can only be accomplished by high velocities — *velocity means powder*— and powder requires enormous strength of gun.'[1]

Another and a more serious exception was taken, to the inadequacy of the bursting charge enclosed in the shell, which, being but 3 lbs. 8 oz., was regarded as insufficient to rend the metal into such a multitude of fragments as to diffuse the widest possible havoc. But there is nothing in this objection that is not susceptible of removal, by altering the form of the projectile so as to increase the dimensions of the chamber, or by substituting some more powerfully explosive chemical combination, in aid or in lieu of that now in use.

Comparisons were likewise drawn at the moment between the resistance of a few square feet of iron of an alleged inferior quality formed into a target, and fixed immovably on land, and that of an iron-clad man-of-war, the breadth of whose sides contribute to the strength of all the parts, and derive some supposed advantage from the yielding medium in which the vessel floats. The encounter between the American iron-clads, the 'Monitor' and the 'Merrimac,' was appealed to as an illustration of the still unconquered endurance of armour. But whatever weight was to be attached to these views, they all

[1] *New York Times*, October 27, 1862.

pointed to the necessity of farther experiments, and precipitancy was deprecated in pronouncing any judgment, or regarding the late trial as decisive of the contest between artillery and iron. It was very fairly represented that in every previous instance the plates in the targets practised upon had been considerably lighter than those in some ships in actual use, and other vessels were then in process of construction, to be coated with armour *five and a half* inches thick, whilst the heaviest plate destroyed by Mr. Whitworth in September 1863, was but *four and a half* inches. Besides this, the question of *range* was still undetermined, and fresh trials were demanded at a greater distance than even 600 yards.

With the latter demand Mr. Whitworth in a letter to *The Times*,[1] signified his cordial assent, coupled with the assurance that his gun, if tested under conditions as trying as those in ordinary warfare, would penetrate stronger defences at greater ranges than any yet tried at Shoeburyness. 'But I would ask,' he continues, 'as I think I am entitled to ask, that the trials be so conducted as to be no longer a charge on my private resources, and that they should be carried on at such time and place as not to compel me to make unnecessary sacrifices.'

These renewed experiments took place at Shoeburyness, in November 1862. The resisting power of the iron employed in previous instances having been proved to be inferior, a new box target was built for the

[1] Oct. 11, 1862.

occasion on the model of the 'Warrior,' but in some particulars stronger. The front was composed of three armour-plates, ranged edge to edge, the upper one being *four and a half* and the centre and lowest one rather more than *five* inches thick, with teak backing, and a skin of ⅝ths of an inch of iron. The weight of the shell was increased from 131 lbs. to 151 lbs.,[1] the bursting contents from 3 lbs. 8 oz. to 5 lbs. of powder, and the charge with which it was fired from 25 lbs. to 27 lbs. Mr. Whitworth had wished the gun to be placed at a range of 1,000 yards, but a gentleman whose house was contiguous objected to such dangerous proximity, and a position was obliged to be taken at 800 yards from the target.

The interest of the occasion attracted a more than ordinary number of scientific and professional spectators, the Lords of the Admiralty, chiefs of the War Department, and members of the Institution of Civil Engineers. The morning was one of unusual brightness and beauty, and the clearness of the air rendered every minute object distinct over the expanse of the dreary marsh where the concourse were assembled. Ranged along its southern extremity, and immediately behind the great embankment that restrains the Thames, stood rows of ponderous targets which showed the evidences of former assaults; in front was the newly constructed one which was to concentrate the

[1] In the projectiles used on this occasion, Mr. Whitworth for the first time so far modified the form of the flat front as to give the centre a slight elevation above the surrounding edges. The effect upon the penetrating or 'punching' power was not obvious to the spectators.

interest of the day, and right and left of it were the 'splinter-proofs,' rude iron sheds designed to shelter spectators from the iron shower of metal fragments which fall when cast-iron projectiles are dashed to pieces in these tremendous encounters. When the bugle had sounded in succession the note of warning and the signal to 'fire,' and before the thunder of the gun could reach the ear, the eye was apprised by the sheet of white flame that played over the face of the target, that the armour had been struck. Smoke issued from every crevice, and so soon as the suffocating vapour within permitted the interior to be examined, it was discovered that the shell, which struck with a velocity of 1,220 feet per second, after traversing the range of 800 yards,[1] had penetrated both the iron and the

[1] The high velocity of the Whitworth projectiles no doubt contributed greatly to their success. Even at 800 yards it was 1,220 ft. per second; that of the Armstrong 110-pounder fired with 14 lbs. of powder is only 1,210 ft. at the mouth of the gun. The velocity of projectiles is ascertained very accurately by means of the electrical apparatus of Navez. Two frames are set up at a given distance, say 30 ft., from each other; each frame is traversed in a zig-zag direction by a copper wire properly insulated and connected with the electrical apparatus. Suppose a projectile fired, it passes through the wire web of the first frame, breaking a wire and contact, and the instant of fracture is recorded at the instrument; the projectile goes on, traverses 30 ft., and then meets and breaks through the second frame and its insulated wire; the exact instant of the second fracture being in like manner recorded. The *time*, the small fractional part of a second, elapsing between the first fracture and the second is ascertained by measuring the arc through which a pendulum had vibrated in the interval. To illustrate this more familiarly, suppose the pendulum to vibrate through a graduated arc of say ten inches in a second, and to carry with it loose upon its axis two pointer needles; No. 1 connected with the insulated wire of frame No. 1; No. 2 needle connected with the wire of frame No. 2. When the pendulum is beginning to descend, the

teak, and bursting in the substance of the latter, had rent the timber into filaments, flinging fragments of broken shell round the chamber within. The plate through which it had entered exhibited minute cracks in various directions, the iron lining was distorted and torn, bolts were started, and one of the massive iron ribs sustaining the armour was snapped asunder.

As portions of the broken shell had been thrown backwards and fallen outside in front of the target, whilst the others were driven forward and scattered within it, it was obvious that again the shell had burst a fraction of a second too soon, and before it had reached what was meant to represent the main deck of the ship. The damage was therefore less than was due from so terrific an explosion, and the gun was again pointed for a second discharge.

Again a shell of the same description was fired, and again it was driven through the top plate of *four and a half* inches of solid iron, traversing the timber in its resistless course, and this time bursting as was intended in the interior of the target, where it left lumps of

operator causes the gun to be fired by electric apparatus also under his control. The projectile is shot forth almost before his lips have ceased to say *fire!* it passes through the first frame, breaking the wire and the electric contact, and causing the needle-pointer No. 1 to be arrested at the exact spot on the graduated arc at which the pendulum had arrived at the instant of fracture; after traversing 30 ft. the projectile breaks the wire of frame No. 2, and then the needle-pointer No. 2 is propped by the pendulum; marking the other extremity of the arc through which the pendulum had swung while the projectile traversed 30 ft. The length of the arc through which it had vibrated being thus ascertained, an easy calculation assigns the velocity required.

metal of various sizes, hot and blackened with the recent explosion, deeply impacted in the beams and wood-work; whilst the floor was strewn with bolt-heads and rivets wrung from their fastenings by the violence of the shock.

To an unexperienced eye the evidences of destruction caused by these and subsequent shots were appalling; but individuals more familiar with such scenes gave expression to their disappointment that the shells had burst prematurely, and that the pieces into which they were rent were not sufficiently numerous and minute, so that the lateral action was less deadly than had been expected. In the judgment of the naval and military authorities, further experience was held to be essential, for a nicer adaptation of the bursting charge within, not only to delay the explosion till the moment of perfect penetration, but to rend the tough metal in which the powder is enveloped into more multiplied and destructive splinters.

On the same day shells weighing 80 lbs., with a bursting charge of 3 lbs. 12 oz., were fired at the same target from the Whitworth 70-pounder: they passed through the iron, but burst in the timber backing without piercing the inner skin or penetrating to the interior. To the latter experiment unusual interest was attached, as the weight of the Whitworth 70-pounder (being under 4 tons) renders it eminently suitable for service at sea. 'To estimate the importance of this portion of the proceedings,' says the writer in *The Times* of the following morning, 'it must be

remembered that other guns, both smooth-bored and rifled, had fired nearly as much as 900 cwt. of shot in single discharges at 200 yards against similar plates without doing more than bending, or at most cracking, but never penetrating them. Yet here was a 70-pounder at 600 yards sending its *shell* clean through. While we state this, however, we must also, in justice to Sir William Armstrong, add, that when he fired his 153 lb. spherical shot against the 'Warrior' target some months before, though he did not *penetrate* the plates, he inflicted a much more damaging effect by shattering them, than Mr. Whitworth did with his 150 lb. shell. Sir William, however, used 50 lbs. of powder at 300 yards range, and Mr. Whitworth only 27 lbs. at 800 yards. . . . . . The result of the day's experiments is a great triumph both for the form and material of Mr. Whitworth's projectile; but to fully utilise the enormous penetrating power of his gun, a still greater explosive force, whether by gunpowder or some other means, must be given to the contents of his *shell*. It is not a clean and easily plugged hole that is wanted in the side of an iron frigate, but a crushing *smash* that makes a hundred radiating leaks which nothing can stop or stanch. Mr. Whitworth has overcome the first and most formidable of all difficulties *by making the hole*; it only remains now to give his shell bursting power sufficient to convert the round hole into a labyrinth of ragged rents: and he has persevered too long to be likely now to stop short at an obstacle like this.'[1]

[1] *The Times*, Nov. 14, 1862.

On November 14, the 110-pounder of Sir William Armstrong was fired against the uninjured parts of the same target which Mr. Whitworth had riddled the day before. The shot was a conical one of 110 lbs. cut short at the base, so as to reduce it to the weight of 68 lbs. This was fired at a range of 200 yards, and with a charge of 12 to 16 lbs. of powder. But in no case did it penetrate the plate or make any indentation exceeding 4 inches in depth, the cone being broken off, and the main body of the metal behind it crushed to pieces.

The proceedings of that day closed by trying the Whitworth 12-pounder with flat-fronted shot and shells of homogeneous iron, against a target covered with $2\frac{1}{2}$ inches of iron, and *inclined backward to an angle of* 45°, an angle at which no gun but Mr. Whitworth's has yet succeeded in sending any projectile through the plate. Two shot made of cast-iron, and only intended to be used as pioneers to ascertain the range, were fired by accident instead of those of hardened steel, and the error was at once detected by their crumbling to pieces. But those designed for the occasion evinced their usual power, completely penetrating the iron in a diagonal line where the inclination increased the thickness to about *three inches and a half*. The shells, which were used without bursting charges, were found to be so little injured by passing through the iron, that they might each have been fired again from the same gun.

With this remarkable scene closed the latest act of

the exciting drama. The false security of armour-plating was disclosed; and the fancied supremacy of iron mail again passed over to its fell antagonist artillery. Only a day before, the ship,

Now girdled with a waist of iron,

had frowned a haughty defiance to all assaults, but the most formidable, although then the least apprehended of her assailants, the shell, was at last in full possession of her boasted defences. The conclusion became inevitable, that solid iron of whatever degree of thickness capable of being borne by a vessel at sea, was no longer invulnerable by such guns and projectiles as had now been brought to bear upon it.

Numerous other trials of various targets and of armour-plate prepared in various ways have since taken place at Shoeburyness and elsewhere, so as to test the difference in effect produced by different weights moving with different velocities, as well as the value of different materials[1] in different forms. But no results have been yet attained calculated to modify

[1] In November 1862, experiments were made by firing the Armstrong 6 and 12-pounders against a target in which *one inch* of iron was backed by a slab of 'mill-board,' *papier mâché* having been tried on a former occasion. But neither the mass of paper pasted together, nor the more solid material of indurated pulp, exhibited powers of resistance equal to that of teak.

As yet no clear conclusions have been arrived at, but all the experiments have served to confirm the previous conviction that steel and *hard* metal, which it was supposed would be most effectual in *resisting* the force of a projectile, are less to be relied on than soft and tough iron, which whilst it *receives* the force, yields to it locally without producing extensive fracture.

this judgment, or to lead to any other conclusion as regards sea-going ships, than that armour-plate of solid iron is no longer to be relied on as a protection against rifled artillery even at extraordinary distances.

In regard to fortifications by land; where the weight of the armour-plate involves no mechanical difficulty, the case may be widely different, nor is there any apparent obstacle to the piling of such masses of solid iron as effectually to resist the blows of the most ponderous cannon. Early in 1863 a target was tried, designed by Capt. Inglis, of the Royal Engineers, to represent a mode of protecting the exposed portions of batteries and casemates fronting the sea, by covering them with plates from 5 to 8 inches thick, the object aimed at being effectual resistance to missiles of any weight capable of being projected at land fortresses from vessels at sea. Four guns were arrayed for this trial, the Whitworth 7-inch bore previously fired with so much success, an Armstrong smooth-bore of 9 inches, and another of 10½ inches rifled on his *shunt* principle, together with one made by Mr. Lynall Thomas, which unfortunately burst during the trial. The 150 lb. shot from a Whitworth gun buried its front in the solid iron, causing what a by-stander described as an 'awful smash,'[1] whilst another of 100 lbs. from the smooth-bore Armstrong produced a broad indentation 2½ inches deep, inflicting serious damage. The third assault was made by the 300-pounder rifled on the 'shunt' system recently invented by Sir William Armstrong (but not yet adopted into the

[1] *Mechanics' Magazine*, March 1863.

service), in which the projectile enters freely by one set of grooves, whence it is literally *shunted* into another series (or rather into shallower parts of the same series), along which it is driven by the explosion; fitting tightly, owing to the ribs or pins of soft metal affixed to the projectile being pressed into or against the sides of the grooves. From this gun a shot weighing upwards of 230 lbs., with a charge of 45 lbs. of powder, struck the target with a velocity of 1,405 feet in a second, inflicting a destructive bruise, and cracking the outer plate. Still, notwithstanding this and other subsequent blows from the Whitworth gun, the ponderous shield, although rent and disturbed, remained practically unsubdued.

But whatever be the future of solid iron upon land, the confidence in the safety of solid iron at sea has been irrecoverably shaken, and as a natural consequence, already other devices have been sought to provide a substitute. Foremost among these is the target of Mr. Chalmers, which was tried at Shoeburyness so late as April last. Faced with hammered armour-plates about *three* inches thick, and backed with nine inches of teak, its peculiarity consists in the ingenious expedient of introducing behind the armour-plates a series of cells of wrought iron $\frac{5}{8}$ inch thick, riveting them at the back to an iron plate of an inch and half. Behind this again comes another pad of teak, resting against the iron skin of the ship. The object of thus interposing the iron webbing is to aid in resistance to the impact of the shot, by distributing the force of

the concussion over a larger area, instead of its being concentrated at the precise point of impact. When tested by the fire of guns of the same power as those originally tried upon the 'Warrior' target, this new structure withstood the attack better than any other of equal thickness that had yet been submitted to experiment. The 68-pounder fired with the full service charge, the 110-pounders, and 200-pounders fired with 10 lbs. of powder, though leaving deep indentations, inflicted comparatively little injury. A salvo 'of two 68-pounders and three 110-pounders concentrated on one spot, struck with a terrific crash, splintering the shot to fragments, which went screaming through the air in all directions; but still the main side of the backing, the skin of the ship in fact, on the integrity of which the success of the experiment depended, showed no sign of yielding.'[1] The target was at last broken up premeditately by a shot from the 300-pounder of Sir William Armstrong, which, as had been foreseen, passed completely through, leaving behind it a ragged and irreparable breach. A flat-fronted shot or shell from the 7-inch Whitworth gun would have proved equally destructive.

At the stage at which we have arrived in 'the Story of the Guns' the question therefore remains for future development, whether any new combination of metal or any ingenious configuration of armour-plate will yet be discovered of sufficient strength to protect an iron-clad ship from the crushing effects of a gigantic smooth

[1] *Times*, April 29, 1863.

bore, like the Armstrong 300-pounder at a range of 200 yards; or to defend it against the assault of the Whitworth rifled gun from still greater distances.

Since the foregoing passage was in type, a 'Warrior' target, fourteen feet square, placed on board a floating raft, at a distance of 1,020 yards, has been tried at Shoeburyness in December 1863. From a 13·3 inch Armstrong shunt gun weighing $22\frac{1}{2}$ tons; both solid projectiles and shell, weighing 600 lbs., were fired with a charge of 70 lbs. of powder, at an elevation of 2·25, and driven clean through, making a hole in the iron-plate two feet long by twenty inches wide. 'The teak backing,' says a writer in *The Engineer* of December 18, 'was rent into fragments, from the merest splinter to the size of a cocoa-nut; and $\frac{3}{4}$-inch plates of iron were torn asunder like paper.'

CONCLUSION.

THE PRESENT ASPECT OF THE QUESTION.

IN any retrospect of these occurrences, with a view to trace their influence upon the present state of the subject, a distinction must necessarily be drawn between the act of the War Office in 1858, in selecting the Armstrong gun for special service in the field, and the subsequent policy, which, by stifling competition and hurrying the introduction (in some instances *without previous trial*) of the heavy ordnance (which General Peel had wisely left for future consideration), has had the effect of committing the Government somewhat hurriedly to the Armstrong system in its utmost extent.

Whatever may have been the alleged insufficiency of the first trials of the rival guns by the Committee of 1858, the Committee of the House of Commons in 1863 have pronounced the formal adoption of the Armstrong field-gun by General Peel to have been fully justified by the circumstances under which the result of those trials was brought officially before him.[1] It is not of the isolated fact of that resolution that

[1] *Report*, p. iv. See the opinion of the present *Secretary of State for War*, to the same effect. *Ibid. Evidence*, 5043.

even those who contest the propriety of the choice have reason to complain; but of the arrangements that followed, which, assuming that the previous decision may have been questionable, opposed a serious obstacle to its reconsideration.

Governments and committees with the utmost purity of intention are not exempt, any more than men and individuals, from liability to occasional error; and true wisdom is manifested on such occasions not in the persistent assertion of an unattainable infallibility, but in a cordial readiness to admit the teachings of advanced knowledge and adopt the corrections recommended by experience. It is to be regretted that this spirit has not been more prominent in the course followed by the military authorities. The permanent attachment of Sir William Armstrong to the government service, and the plurality of employments created for him, justified the statement of Colonel Lefroy, that the War department having possessed themselves of his system, '*was bound to work it out*.'[1] And even when the sufficiency of the Armstrong plan of breech-loading was questioned, the only admission called forth was the declaration of the same authority, that 'the Government, having deliberately adopted it, *must take the consequences*.'[2] A misconception as to the wishes and wants of the public is apparent in a policy such as this; the Government ought *not* to feel itself help-

[1] *Evidence of the House of Commons' Committee on Ordnance*, 1862, 355.

[2] *Ibid.* 289.

lessly 'bound to work out' any system in despite of a reasonable prospect of exchanging it for a better; or 'to take the consequences' of any act, provided they can be averted by timely precaution.

So far from ascribing this absolute finality to departmental decisions, if questionable they ought to be upheld only till opportunity offers for superseding them by more advantageous arrangements; and any measures calculated to thwart or defer such a salutary change, must be more or less inconsistent with the true interests of the nation. There is no one of the great military Powers of Europe whose entire freedom of action in the choice and introduction of artillery is embarrassed by arrangements at all analogous to those which recently existed in England. And although by Sir William Armstrong's retirement from his several offices, he has relieved the Crown of its obligations so far as they were affected by his official relation, one formidable obstacle still remains in the fact of the vast amount of capital expended upon guns and ammunition peculiar to his invention.[1] This outlay operates practically as a bond, by which, under a penalty of *two millions and a half sterling*, the country is deterred from attempting any change.

[1] 'I must confess,' said Captain A. W. Jerningham, R.N., an officer of the most extensive experience, 'that when I used to go to Woolwich and see the hundreds of 100-pounder Armstrong guns lying about, manufacturing and being issued, it used to strike me that *we were going on too fast* in laying out so much money on these big guns before their perfection was complete.'—*Evidence, House of Commons' Committee on Ordnance*, 1863, 3661, 3749.

But it is not alone the magnitude of the sum that will cause the country to reflect; it is the farther consideration that the whole of this immense expenditure, and of the vast operations extending over a period of five years, between 1858 and 1864, have been carried on exclusively 'for maturing and perfecting the Armstrong system of rifled ordnance,'[1] which by an unanimous concurrence of opinion, including that of the author himself, is not yet 'matured;' and so far from being 'perfect,' the present superintendent of the Royal Gun Factory declares that he '*does not think very much*' now of the Armstrong gun chosen by the committee of 1858 in preference to the Whitworth; and although the guns made for the Government since are much better than those of 1859 and 1861, 'he *thinks the guns of last year are very bad in many particulars*.'[2] This is the evidence of a gentleman whose professional reputation stands so high in the estimation of one of the naval captains examined (himself a rival inventor), that he calls him 'the ablest mechanic in the world without exception,'[3] and Mr. Anderson's authority in this instance rests upon the fact, that in his confidential relation to the Government he has been conversant with the making of the Armstrong gun from the commencement. His language is even more portentous than the expressions above quoted, for in reply to a farther

[1] See *Definition of Sir William Armstrong's Duties, and Terms of his Appointment by the War Office, Feb.* 23, 1859.

[2] *Evidence of* Mr. ANDERSON, *House of Commons' Committee*, 1863, 765.

[3] *Evidence of* Captain SCOTT, R.N., 4387.

enquiry, he recommends the Government to begin entirely *de novo*, and, '*whatever the past may have been, to throw it behind us, taking advantage of the experience now gained, and let bygones be bygones with respect to the manufacture of ordnance.*' [1]

This counsel, after an expenditure of upwards of *two millions and half* sterling, is by no means consolatory; especially when coupled with a still later assurance from the same authority (second only to that of Sir William Armstrong himself), that 'within a few years we shall be very much dissatisfied with what we are even now doing.' [2]

It must not be overlooked that whilst this is the dubious condition of the Armstrong gun, the system of rifling tendered by Mr. Whitworth so many years ago remains to the present time unaltered in any particular; nor has the confidence of its inventor undergone any diminution, either as to the power or precision of his own gun. It awaits its trial now, in precisely the same condition as that in which it was offered in 1858; and its author has uniformly declared his inability to improve it.[3]

During all this long period, says the First Lord of the Admiralty, the Duke of Somerset, 'the whole process has been an experiment, and I consider that the War Office and the Admiralty have been experimental departments. We have been experimenting largely; but

1 *Evidence of* Captain Scott, R.N., 753.
2 *Ibid.* 755.
3 *Letter* of Mr. Whitworth to *The Times*, Feb. 28, 1860.

it cannot be helped.'[1] Protracted experiments were no doubt unavoidable, and the outlay already incurred has been cheerfully borne by the country under the belief, not that 2,539,547*l.* 17*s.* 8*d.* was to be devoted exclusively to reproduce and improve the gun of *one single inventor*; but that, in the course of its disbursement, every opportunity would have been eagerly availed of to compare and determine the value of other competitive systems of rifling.

Other inventors suffer under the disadvantage of defraying the cost of their experiments from their own private resources, whilst those of Sir William Armstrong have been carried on at the public charge; but it is not of that they complain so much as of their exclusion from the contest, and of the official difficulties which they allege have been interposed to obstruct comparative trials of their guns. Amongst others, Captain Blakely, whose gun has since attracted much attention in other countries as well as in England, says he applied in 1860 to have a rifle gun tried in competition with the Armstrong and Whitworth, conforming in all respects to the programme of the War Office. He offered[2] to conduct all the experiments at his own expense; but the offer he says was refused, and though 'repeated several times since, it has always been refused.'

There have been, however, many exceptions to this

[1] *Evidence, ibid.* 5222.

[2] *Evidence of the Select Committee of the House of Commons on Ordnance*, 1863, 4744, 4756, 4029.

practice; trials were instituted, as before stated, in 1860, in the course of which six methods of rifling were examined with a view to the selection of the best for the purpose of utilising the old smooth-bore cast-iron guns which had been superseded by the introduction of rifled ordnance:[1]— and in 1863 Mr. Westley Richards was afforded facilities for trying his plan of breech-loading in substitution of that of Sir William Armstrong: but these, and other instances, have not been sufficiently frequent to counteract the general discontent.[2]

Even as spectators of the experiments by the Ordnance Select Committee, it is not open to scientific men and civilians with sound practical knowledge of the subject to be present unless specially invited. Mr. Westley Richards stated to the House of Commons' Committee that when he applied for permission to witness some trials of large guns on an occasion on which Sir William Armstrong's, Mr. Whitworth's, and Mr. Lynall Thomas's were to be fired, he was refused. He was 'told at the War Office that none but military and naval men could be allowed to be present.'[3]

In the great struggle for ascendency between armour-clad ships and rifled ordnance, the difference is apparent between the feelings with which practical men regard the course pursued by the *Ordnance Select Committee* to determine which is the *gun* possessed of the utmost force for assault: and that adopted by the *Committee*

[1] See *ante*, Part II. chap. i. p. 84.

[2] See *post*, p. 335.

[3] *Evidence, &c.*, 1863, 3993.

on Iron Plate to discover the *metal* endowed with the highest power of resistance. As regards the latter body, which is composed partly of naval and military officers and partly of civilians eminent in various branches of science, not a murmur of discontent has reached the public; no producer of iron has complained of exclusion, and no ingenious constructor has imputed partiality. On the contrary, the proceedings of the Iron Plate Committee have, up to the present, been received with implicit confidence, as the deliberate acts of men eminently qualified by their skill in metallurgy, and their experience as engineers and workers in iron, to assist their naval and military colleagues in coming to just decisions. Hence, while the progress already made, and the important facts elicited, cannot fail to be conducive to an ultimate result of the utmost value in guiding the selection of the most suitable metal, and its use in the most available form for the construction of an iron navy, no equivalent results as regards the selection of the most powerful rifled gun have as yet accrued from the proceedings of the Ordnance Select Committee.

It admits of little doubt that the main cause of this disappointment is to be traced to the constitution of the latter body, and to the want of certain essential qualifications in its members. There is perhaps no single problem of modern times that embraces within itself the same multiplicity and variety of elements, drawn from the profoundest resources of numerous branches of physical science, as that which now occupies the

attention of the Ordnance Select Committee of the War Office; and yet, anomalous as it may seem, the list of that Committee, with possibly one exception, includes no name of the highest eminence amongst the cultivators of science in any department. Its members are taken exclusively from the army and navy, and whilst the fact of an officer being chosen for so important a duty is an honourable testimony of his personal and professional distinction, it admits of no question that service afloat or in the field, does not of itself impart the enlarged acquirements essential to decide the abstruser questions involved in the pending enquiry. Mere familiarity with the *use* of an ingenious instrument does not necessarily imply such a philosophical knowledge of its form and proportions as would enable its possessor to weigh the theory of its mechanism or pronounce on the construction of its parts. To assume this is virtually to imply that the wearer of a watch, is thereby entitled to speak with authority on the complex and delicate movement of a chronometer;—and although the course of education laid down for the artillery includes the study of mechanical engineering as connected with ordnance; professional duty is so little favourable to its practical cultivation, that there are few in the service of whom it could be said, as has been told of the late Emperor of Russia, that he could have assisted with his own hands in the making of every military weapon from a musket to a 42-pounder.

It was apparently from a consciousness of this want of men of practical science among the advisers of the

War Office, that during the campaigns in the Crimea the exclusively military character of the *Ordnance Select Committee* was so far relaxed as to admit of the introduction of two civil engineers, a mathematician, a professor of chemistry and a gentleman eminent in almost every branch of philosophical mechanics. But the alteration was not permanent; and those who have devoted their attention to the improvement of rifled ordnance, whilst rejecting the idea of deliberate injustice, have very generally expressed their regret at the failure of their attempts to obtain such practical trials of their invention, or such decisions in relation to them, as ought to inspire confidence in the competence as well as in the impartiality of their judges.

Not civilians alone, but naval and military officers[1] whose professional experience enabled them with great effect to apply their minds to render artillery more effective, concur in complaints of what is designated as 'the system' of the War Office, a term which, under the form of an abstraction, conceals the absence of individual responsibility. It is the function of the Ordnance Select Committee to advise the Secretary of State for War on all improvements suggested in the construction of artillery; and it is described as their

[1] See the evidence of Captain R. A. E. Scott, R.N., and of Captain A. Theophilus Blakely, before the *Select Committee of the House of Commons on Ordnance*, 1863. Captain Scott can only account for the difficulties which were opposed to the institution of trials of the guns of Mr. Bashley Britten and others, by the conjecture that there was a predetermination '*to make some plan of Sir William Armstrong succeed;* and therefore that others who brought forward systems of rifling were delayed.' *Ibid.* 4252.

practice to ‘recommend either that the proposal should be discouraged if not worthy of acceptance, or that experiments should be carried out to test its value as an invention.’[1] But the grievance appears to be that, owing to the want of practical and eminently scientific men on the committee, it is in reality almost a matter of chance what proposals are entertained, what dismissed without trial, and what left entirely unnoticed.[2] The Duke of Somerset reluctantly attests the existence of this distrust; and says that many of the inventors ‘used to come to him at the Admiralty, because they said they did not like the Ordnance Committee’ at the War Office.[3] And as an illustration of the difficulties interposed by ‘the system,’ his Grace goes on to state that after witnessing the performance of the Whitworth gun, when it penetrated the armour plate of the ‘Trusty,’ and ‘*could have sunk her*,’ he says, ‘*with one or two shots*,’[4] he felt desirous to have some of these guns manufactured, and obtained the concurrence of Lord Herbert, who was then Secretary of State for War; but the Ordnance Select Committee not having tried or approved of Mr. Whitworth's mode of rifling, his attempt was defeated.

Of late the active preparation of Armstrong guns has

[1] *Evidence of* Colonel Lefroy, *House of Commons' Select Committee on Ordnance*, 1862, 158, 166; and of General St. George, *ibid.* 2752, &c.

[2] *Ibid.* Mr. Westley Richards ‘does not think they (the Ordnance Select Committee) assist inventors *as if they desired* their inventions to succeed. *Ibid.* 4027, 4029.

[3] *Ibid.* 5145.

[4] *Evidence, Committee of* 1863, 5184, &c.

been slackened at Woolwich, and ceased altogether at Elswick. No land service 12-pounders have been made for a long time, and the manufacture for the navy has been confined to 70 and 40-pounders.[1] Of about 3,000 pieces produced in all, 2,370 of various calibres have been issued for land and sea service.

As regards the estimation in which it is held by the army, the opinion expressed by Colonel Gardner of the Royal Artillery, who holds the appointment of Chief Instructor in Gunnery at Shoeburyness, may be fairly assumed to represent the sentiments of the service in general. 'My general impression,' said Colonel Gardner, 'is this, that the gun is a very accurate gun; I may say remarkably accurate: that with considerable care it would be a useful gun; but that I have considerable doubts at present whether it is so formed as to stand the rough usage of service. Its weak points in my opinion are the *vent-piece* and the *breech-screw*. The vent-piece is defective in strength, and the breech-screw is liable to injury, from the fact of the face of the breech-screw being indented by the vent-piece breaking. If the surfaces of the vent-piece and of the breech-screw are not true, you have a concavity made on the screw, and you may go on breaking vent-pieces as often as you like. From what I have observed, I should be inclined to think that that would always be a great defect in that description of gun.'[2]

[1] *Evidence of* Major-General Tulloh, *House of Commons' Select Committee on Ordnance*, 1863, 2681, &c.

[2] *Evidence of the House of Commons' Committee on Ordnance*, 1863, 8.

Colonel Gardner illustrated his conception of the care indispensable to insure the safe working of the Armstrong gun, by quoting from the formal 'instructions' a passage explanatory of the necessity of the surfaces of the breech-screw and the vent-piece being true, in order to insure close contact, and thus prevent the injurious consequence of permitting the gases of explosion to escape; it was this: 'The allowance between the nose of the vent-piece and powder-chamber should be exactly $\frac{2}{1000}$ths of an inch, or $\frac{4}{1000}$ths difference in diameter. If less than this is allowed, any burr or upsetting of the vent-piece nose will cause it to jam in the gun, and if a greater allowance is given, the edges of the cup will be split open and blown by the gas into the space, and the faces will be destroyed.'

'That,' continued Colonel Gardner, 'is where I think the failure will still arise, because *nobody, or at least not one man in a hundred*, when at all excited, would look, or, in fact, have the means of ascertaining that those dimensions are exactly true; then, if this burr occurs, or if these fittings, when you come to *thousandth parts of an inch*, are not observed, you will probably have the result apprehended.'[1]

This statement had immediate reference to heavy guns, but 'the same results of breakage, which are the effects of using the breech-screw, will *apply to the whole system*; but not, perhaps, in the same degree in

[1] *Evidence of the House of Commons' Committee on Ordnance*, 20.

the smaller guns, of course.'[1] In addition to this, he objected to the complication of the arrangements, and the use of detached pieces and delicate screws, which 'a handful of dust' must at any moment clog and disable. Looking to these and other doubtful points, he 'would be glad to see the whole subject opened, as at present we are in a very unsatisfactory state.'[2]

Colonel Bingham, Deputy Adjutant-General of Artillery, on the first introduction of the Armstrong gun into the service, and down to the autumn of 1862, 'had perfect confidence in it in every way,'[3] but owing to a series of mishaps which since occurred, that confidence was shaken. In illustration of this, Colonel Bingham mentioned one occasion at Shorncliffe, when in the course of ordinary practice, 'six of the guns became very much damaged, in fact unserviceable.' He also stated that owing to 'bad manufacture' and the false economy of 'lining' guns that showed signs of weakness while undergoing proof, 'he believed that more than half the guns we have now in the field are these faulty guns.'[4] Still he is perfectly satisfied with the smaller

[1] *Evidence of the House of Commons' Committee on Ordnance*, 23, 112.

[2] *Ibid.* 74, 106, 137.

[3] *Ibid.* 366.

[4] *Ibid.*, *Evidence of* Colonel BINGHAM, 384, &c. There is some obscurity about the explanations given with reference to the 'patching of these guns,' as well as to the extent of the damage thereby occasioned. It seems that the authority to line the defective guns emanated from the Ordnance Select Committee. (*Ibid.* 551.) The Committee of the House of Commons in their recent *Report* quote the following passage from the evidence of Mr. ANDERSON: 'If I had known that those linings would have been spoken of, or if Sir WILLIAM ARMSTRONG had known it, we should not have lined them; we would have bored them out.

field guns introduced in 1858, if properly manufactured; no other country, in his opinion, is possessed of a better, and this, he thinks, is the opinion of artillery officers in general; and *as far as he has seen* he would prefer it to the Whitworth.[1]

Major-General Sir Richard Dacres, who commanded the British artillery at the siege of Sebastopol, states on the report of the officer commanding the Horse Artillery at Woolwich, that owing to the flaws, only ten out of sixty-six Armstrong guns were effective.[2] And although he thinks it, notwithstanding 'a great many defects, the best rifled gun known; still he would not consider it safe to rely on it entirely, in the field.'[3]

The Duke of Cambridge, as Commander-in-Chief, speaking on behalf of the land service, has given a similarly guarded opinion: — 'The Armstrong gun,' he says, 'is not perfect, but is the best gun *so far as we have gone*, and the most perfect system *we have yet had laid before us*.' Of the Whitworth gun His Royal Highness 'will not say whether it is a good gun or a bad one, because it is now under experiment, and it has

They were to be made for 200*l.* a piece, and they have been made at 87*l.*; and now, working that price up to 100*l.*, I have made them as good as any guns that were ever made.' 'He positively denies,' adds the *Report*, 'that the lining complained of by Colonel Bingham was the cause of the failure of the guns. On careful investigation your Committee find that out of 570 12-pounders issued and in use, 13 only have been returned to the royal gun factories for repair, 3 of which have proved unserviceable, and the remainder repairable at an inconsiderable expense.' (p. vii.)

[1] *Evidence of the House of Commons' Committee on Ordnance, Evidence of* Colonel Bingham, 374, 524, 534.

[2] *Ibid., Evidence of* General Sir Richard Dacres, 2,182.

[3] *Ibid.* 2,184–86, 2,193.

never been introduced as a system so completely as the Armstrong gun.'[1]

The majority of the above exceptions have been taken, it will be seen, on the ground of its being a breech-loader. 'The preponderance of opinion,' as reported by the House of Commons' Committee of 1860, 'seems to be against any system of breech-loading for larger guns.'[2] But as regards field guns, the same Committee state 'that the officers who commanded Armstrong batteries in the late operations in China found no difficulty in keeping them in order in all weathers and under all circumstances.'[3] This, however, admits of some qualification, as 'there was no rough work in China' to afford opportunity for a thorough trial.[4] And in the Chinese war,[5] as well as in the more recent service in New Zealand and the Feejee Islands, the official reports of the performance of the gun do not agree in all particulars with the experience and evidence of individual officers.[6]

Whilst the opinion in the army is thus unsettled as

[1] *Evidence of the House of Commons' Committee on Ordnance, Evidence of the* Duke of CAMBRIDGE, 1,233, 1,239, 1,240.

[2] *Report*, p. viii.

[3] *Ibid.* p. vii.

[4] *Ibid., Evidence of* General Sir RICHARD DACRES, 2,228–30.

[5] Colonel GARDNER in his evidence says: 'One of our officers in reporting from China, states that on the morning of August 22, on returning to Sinho, after having bivouacked at Tangku in the rain, the breech-screws were nearly completely jammed with rust, and if we had had to renew hostilities at daylight that morning, the gunners, who were already over-fatigued, would have been severely taxed in getting the guns in working order.' *Ibid.* 101.

[6] See evidence of Captain BEAUCHAMP SEYMOUR, *Ibid.*, p. 98; and *Appendix*, pp. 465, 470.

to such of the Armstrong guns as are suited for land service, the feeling of the navy is still less satisfactory as regards such of the heavy ordnance as have undergone trial at sea. Captain Sir William Wiseman, R.N., formerly a member of the Ordnance Select Committee, when examined by the House of Commons' Committee of 1863, in reply to a request for his opinion generally with respect to the Armstrong gun, reiterated apprehensions similar to those expressed by Colonel Gardner as to the insecurity of the breech-loading apparatus. Owing to recent improvements, however, he thinks that 'up to 40-pounders the guns are now very perfect, but all above that calibre will have to be very much improved to render them fit for the service;' this improvement he 'has no doubt will come, but he thinks it will take a long time. Frequently we have been told by Sir William Armstrong that he has discovered some particular metal that has got rid of the chance of the vent-piece breaking, and for some little while all has gone on very well, but then, after a time, we find the vent-pieces breaking again.' [1]

Sir William Wiseman considers that 'so far as range and accuracy go, we have no system of rifling yet that has excelled the Armstrong, and very few that come near it at all. From what he has seen of Mr. Whitworth's guns, he thinks them quite equal in range and accuracy;' but having already got Sir William Armstrong's in the service, he does not think, looking to Mr. Whitworth's last system of projectiles, that there is

[1] *Evidence*, 175, 292, 297.

any such superiority, as would justify the change from Armstrong to Whitworth guns.

Even on the point of *accuracy*, there are differences of opinion in the navy. Captain Hewlett fully agrees with Sir William Wiseman in this particular; but Captain Wainwright, in command of the 'Black Prince,' told the Committee of 1863, in reply to the question whether he considered the Armstrong gun 'safe, reliable, and effective for arming the navy,' said: 'It is a gun that I should be sorry to see generally introduced into the navy. I do not think the practice from the Armstrong gun is so accurate in bad weather as the practice from the smooth-bore. On board the "Shannon," the ship rolling, perhaps, eight degrees, although the captains of the Armstrong guns were picked trained men from the "Excellent," the firing from those guns was worse than any firing I ever saw in my life; it was so bad that I stopped the fire of the Armstrong guns, thinking it was actually throwing the shot away. On board the "Black Prince," we have fired at a target, the ship rolling to the extent of 16 degrees each way, and I consider the practice made by the smooth-bore, which on board the "Black Prince" is a 68-pounder of 95 cwt., was better than the practice from the Armstrong gun.'[1]

Captain Cooper Coles, R.N., who has signalised himself as the inventor of the *cupola*, for protecting ships of war, is more alarmed than Sir William Wiseman for the failure of the vent-pieces. In firing two 40-pounder

[1] *Evidence* 3,777. See also the opinion of the Earl of LAUDERDALE to the same effect, *Ibid.* 2,140.

guns on board the 'Trusty,' so many mischances occurred (one gun breaking seven vent-pieces, and one other four), that between two and three days were lost in getting artisans from Woolwich to effect the repairs. Both Sir William Armstrong and General Tulloh, the *Director of Ordnance*, are of opinion that the new pattern will prevent the recurrence of such accidents; but Captain Coles, speaking of the 100-pounders as well as of the 40-pounders, says that he has ascertained it to be the feeling of naval officers as well as his own, that so long as the liability remains, there must be 'great danger between decks;[1] and that under any circumstances, guns with less complication would be preferable in time of war.'

As to the 110-pounders, so difficult has it been found to provide an effectual arrangement for breech-loading, that the feeling is very general in the navy, that in its present condition, caution is desirable as to the proportion in which they ought to be employed in the service.[2] 'They were originally required,' says the Committee of the House of Commons, 'for use against wooden ships, and, whilst not sufficiently powerful for penetrating iron-plate, they are as yet imperfect for general naval service, owing to the difficulty of managing and manufacturing the vent-piece.'

It is undeniable that many of those accidents are the result of incaution and inexperience, and that with

[1] *Evidence of the House of Commons' Select Committee on Ordnance*, 1863, 1,561, 1,569, 1,572, 1,601.

[2] See the *Evidence of the Ordnance Committee of the House of Commons*, 1863; the Earl of LAUDERDALE, 2,159; Admiral DACRES, 3,188.

farther practice and greater intelligence, they may to a great extent be provided against.[1] But even then 'it is on all hands admitted that although useful as chase guns, they ought not to be introduced as broadside guns.[2] For the former purpose and in their present proportion, the First Lord of the Admiralty is of opinion that the navy has not got too many of them. But this declaration of the recent Committee, based as it is on the evidence of the Duke of Somerset, announces the serious conclusion that for what constitutes the main armament of the British navy, *the broadside guns,* we are still absolutely unprovided, and after the immense expenditure of the last five years upon the Armstrong gun, that '*we have nothing better now for close quarters than the 68-pounder!*'[3]

In answer to the question, 'Does your Grace consider the 100-pounder has proved itself a satisfactory gun for the naval service?—I think not entirely; I believe that it has some great advantages and that it has some defects. In October 1860, I was anxious to obtain some 100-pounders to try them as pivot guns; I had great doubts whether they would answer completely as broadside guns; subsequent experience has tended to confirm the opinion that though it is very desirable to have some on the upper decks, and some in gun-boats, yet for broadside purposes it has not proved so good a

[1] *Evidence of the Ordnance Committee of the House of Commons*, 1863, *Evidence of* Captain A. Cochrane, R.N., 2,267. See also *Report of* General St. George and Colonel Bingham, *Appendix*, p. 351.

[2] *Ibid., Report*, p. vii.

[3] The Duke of Somerset, *Evidence, Ibid.* 5,109.

gun as we expected; the Committee must remember the difficulty we were in; we had a report that the Armstrong gun had the greatest range and the greatest power of penetration of any gun tried; when we came to try it ourselves that was not confirmed by the facts; the Armstrong gun at a great distance may have had greater power of penetration, but for naval purposes at 200 yards it certainly had not the greatest power; *our old 68-pounder is a more powerful gun than the 100-pounder Armstrong gun.*' 'In short,' says His Grace, 'the question is so much in a transition state, that *when I was this year asked what gun I approved of for the navy, I was obliged to say that I really did not know.*'[1]

The full import of this disclosure can only be estimated in connection with the important fact, that since the adoption of armour-plating by the naval powers of Europe, the issues of actions at sea must henceforward be decided by guns capable of penetrating iron-clad ships; and yet the Committee of the House in its recent Report declared that *against iron plates* the old 68-pounder, which had never produced any effect otherwise than by bruising them, is still 'the most effective gun *in the service*.' I must venture to say, that this summary judgment appears to me to be precipitate, nor do I believe that the Armstrong gun yields in power to the 68-pounder. There is in fact evidence to the contrary;[2] but the issues involved are so numerous

[1] The Duke of SOMERSET, *Evidence*, 5,102, 5,118.

[2] *The Times* of December 9, 1863, says, 'Experiments have established beyond question that even at close ranges the 110-pounder produces

and the results hitherto established so inconclusive, that the Duke of Somerset, on this very point of the com-

at least an equally powerful impression upon thick iron plates as the 68-pounder, provided it be fired with shot and charges of the same weights respectively as those of the 68-pounder. *Under these simple* conditions the 110-pounder may be rendered as effective against iron-clad ships as the 68-pounder; while the same gun, with different ammunition, will far exceed the 68-pounder in range, and at long distances will greatly surpass it in destructive power. This is a point of the highest practical consequence, and one upon which the public have been led to entertain most erroneous notions. Even the Committee themselves in their *Report* propagate the error that "the old 68-pounder is the most effective gun *in the service against iron plates*" (*Report*, p. vii.); and this, notwithstanding the following decided evidence of the Duke of SOMERSET to the contrary, his questioner being Sir JOHN HAY, the President of the Iron Plate Committee, under whose direction all experiments on this subject are conducted:—

"5,133. Have not a great many experiments recently been made with shot weighing about 69 lb., fired from the 110-pounder Armstrong gun, with the old 68-pounder charge of powder?—Yes.

"5,134. *Has not the initial velocity of that projectile so fired been* found to be greater than that of a 68-pounder?—Yes; and that has helped to correct one of our errors. It was imagined that a smooth-bore gun must have greater velocity than a rifled gun. That was an error which we have corrected gradually with increased experience. Those experiments have tended to put us right on those points.

"5,135. It has been ascertained by experiment that the 110-pounder can be used at short ranges, and with the same charge, as the old 68-pounder, with a heavier shot, with the same effect?—Yes.

"5,136. The same tube [i.e., gun] can also be turned to another purpose, namely, precision and great range, with a lower charge of powder, performing a duty which a smooth-bore gun is not capable of performing?—Yes.

"5,137. You would then have a gun which combined great power and great initial velocity at a short distance; and the same gun would also do with another projectile at a greater distance?—Yes." *2nd Rep.* 253.

'From an official report of one of these experiments made a year ago we quote the following details:—A 68-pounder and an Armstrong 110-pounder were fired side by side, at 200 yards' range, against an iron target. The shot used for the guns were of cast-iron, of the same quality; that for the 110-pounder weighed 68 lb., and that for the 68-pounder

parative merits of the 68-pounder, says, it will probably 'take years to come to a satisfactory decision.'[1]

But pending farther experiments, the significance of this passage in the Report is apparent when it is borne in mind that the Whitworth gun, which so signalised itself by being the first to send shot and shell through armour-plate as ponderous as that which guards the sides of the 'Warrior,' is not yet '*in the service*,' although it was long since placed at the disposal of the Government. Should war therefore supervene to-morrow, with any of those Powers which simultaneously with ourselves have been engaged in the study of rifled ordnance, the British navy would be found provided with no better broadside gun than the 'old 68-pounder,' which is confessedly inferior to the improved artillery of other countries, but still, as against iron plate, is stated on this high authority to be 'more effective than the Armstrong gun.'[2]

weighed 66 lb.; the charge of powder was, for each gun, 16 lb. The indent made on the plate by the 110-pounder was exactly three inches in depth; while that made by the 68-pounder was exactly two inches in depth; the velocity of the 68-pounder, which was taken at 200 yards from the gun, was 1,367 feet per second; that of the 110-pounder, which was taken at 530 feet from the gun, was 1,443 feet per second. The next shot from the 110-pounder indented the iron plate 2·7 inches, and maintained a velocity of 1,467 feet at the same distance from the gun.'

[1] *Evidence, &c.*, Duke of SOMERSET, 5,109.

[2] The Earl of LAUDERDALE in his evidence (2,146) explains that his preference for the old 68-pounder was because it will take a larger charge of gunpowder than the Armstrong gun; and, consequently, with a wrought-iron shot, will be more destructive to iron plate at close quarters. But this argument does not apply to a rifled gun so *constructed as to take a charge equal to that of the smooth-bore*; and the weight of the projectile being the same in both, the difference in destructive effect is largely in favour of the former.

If then we are to accept it as represented, that the most effective piece in the British navy is one which has never penetrated iron plate, it follows that in the event of hostilities we should be engaged with an enemy whose cannon can pierce our armour-plated frigates, whilst 'we have not a gun *in the service* sufficiently powerful to destroy an iron-clad ship with comparative certainty.'[1] If this be so, the gravity of the situation reduces all other issues to insignificance: it is no longer a dilettante discussion between inventors as to priority of discovery, or a complacent defence of departmental sufficiency—it is the absorbing and earnest enquiry of the nation, ARE WE ARMED FOR WAR?

Even were we less disquieted by considerations arising out of the state of matters in our own gun factories and workshops, this preponderant question would be forced upon us by the demonstration of what is taking place in other countries; by the knowledge of what is silently in progress in France and Prussia, but above all by the startling display of what is passing on the sea-board of America.[2] Without assuming that our armour-clad ships are in any respect inferior to those across the Atlantic, prudence would counsel a more minute comparison than has hitherto been instituted. But as regards our own ordnance both for land and naval service, it is not possible to avoid an early enquiry, not merely into the crushing and destructive

[1] *Evidence, &c.*, Captain BLAKELY, 4,607, 4,610.

[2] Whilst these pages have been sent to press, an officer of the Royal Navy has, it is said, been despatched by the Admiralty to *Charleston*, to report on the artillery now used in America.

forces of Dahlgren and Parrot guns, as compared with those of the Mersey Company and the 600-pounders of Sir William Armstrong, but even into the penetrative power of our own ordnance contrasted with that now manufactured in the United States.

As regards our preparedness for war, we can speak with confidence of the success attained by equipping the *infantry* with the rifled musket. On behalf of the *artillery* the Duke of Cambridge declares that although he 'cannot say we have a perfect weapon, we have as good a one as we can expect with our present experience,' and the conviction of His Royal Highness is, 'we are ahead of any other country.'[1] But as regards *the naval service*, the advanced guard of our shores, we are now warned by a Committee of the House of Commons that the rifled ordnance of Sir William Armstrong is held by them to be less effective against iron-plated ships than the *Brown Bess* of the navy, the old cast-iron 68-pounder!

Sir William Armstrong, in a very able paper, the discussion of which constitutes the most interesting portion of his evidence when under examination by the Select Committee of the House of Commons in 1863, has given, along with a condensed history of the official transactions connected with his gun, a clear exposition of his own views on the principal points contested regarding its construction, and an explanation of the defects ascribed to its performance. In the course of this exhaustive disquisition, he repeats his preference

[1] *Evidence, &c.*, 1,217, 1,251.

for steel as the proper metal for ordnance, provided only that it can be produced in masses of sufficient size and uniform texture, and he declares, whilst admitting that welding is objectionable in barrels in all cases, that he has nevertheless felt constrained to adopt welded coil as the only alternative, pending the improvement of steel.[1]

His course in this respect differs from that of Mr. Whitworth, who, on his conviction of the superiority of mild steel, has forborne to resort to any substitute which he conscientiously thinks inferior; although, by so doing, he has no doubt furnished a plea for deferring the trial of his heavy ordnance. Is it on this ground, as Sir William Armstrong explains, that the Whitworth guns have never been 'submitted to the authorities,' that they are 'a matter for the future rather than the past,' and are not 'regarded as models for adoption into the service.'[2] Is it not to be regretted whilst each of the two great rivals was thus engrossed in search of one and the same object, the acquisition of a metal possessed of the high qualities essential to the heavy ordnance of both, that the means and facilities incident to the official position of Sir William Armstrong should not have been directed to promote and develope the production of steel instead of being applied solely to the manufacture of its temporary substitute, welded coil?[3] It is probable that for the amount expended upon machinery for making the inferior article at the factories of Elswick and Woolwich (machinery which the

[1] *Evidence, &c.*, p. 134. [2] *Ibid., &c.*, p. 142. [3] *Ibid.* 135, 138.

successful manipulation of steel may at any time render partially if not entirely superfluous) works might have been created equal to those of Rhenish Prussia, and England put in possession of this highly-prized material.

As to *breech-loading*, Sir William adverts to his original statement in 1860, to show that whatever may be its advantages in theory, he has never thought it advisable to apply it except to guns of small dimensions.[1] The difficulty in connection with the vent-pieces of the heavy ones he feels every confidence has now been surmounted, by imparting to it the side movement, on a plan approved by the Ordnance Select Committee. At the same time, on account of its weight, the vent-piece for a large gun 'becomes a serious objection,' and he is not and never has been satisfied with that arrangement.[2] It may here be stated that there is at present under trial at Woolwich a gun made on a plan proposed by Mr. Westley Richards, with a view to substitute a safer breech-loading apparatus in lieu of that in use by Sir William Armstrong, and the results hitherto are said to be highly satisfactory.[3]

As to the mishaps that have occurred with the Armstrong guns, Sir William has gone into explanations to show that their frequency has been exaggerated, and that those ascribable to vent-pieces were chiefly confined to the earliest produced at Elswick and Woolwich, at both of which places the manufacture has been signally improved since 1858.[4] Whatever accidents

[1] *Evidence, &c.*, 135, 138.
[2] *Ibid.*, 3,265, 3,560.
[3] See *ante*, p. 315.
[4] *Ibid.* 3,231, 3,464, 3,486, &c.

may have happened with the Armstrong gun, he shows that they are not to be compared in frequency or number with those incident to the old smooth-bore cannon: and that incaution is the main cause of both.[1]

The mere form of *rifling* Sir William considers subordinate to the question of how to build up a gun securely; and the faculty of doing this constitutes, he says, the essential part of his system.[2] He adduces the

[1] *Evidence, &c.*, 3,265.

[2] *Ibid.* 3,495. This and other disquisitions as to certain characteristics of the Armstrong gun, have led to some obscurity as to what positively constitutes the *essential elements of the Armstrong 'system.'* In the course of the recent enquiry by the House of Commons' Committee, questions were put by Captain JERVIS, one of the members (2,368, &c., and 2,375), implying that in 1858 the selection of Sir WILLIAM ARMSTRONG's gun was inevitable, because he alone had propounded a 'system' of rifling, including the entire construction of a gun and its projectiles; whereas Mr. WHITWORTH at that time had nothing to exhibit except a brass cannon belonging to the Government, the block of which had been rifled by him. The tendency of these questions was to show that the 'system' of Sir WILLIAM ARMSTRONG, besides a particular application of metal in the manufacture of an entirely new gun, comprehended an arrangement for breech-loading, a peculiar form of projectile, a percussion-shell and time-fuse, a pivot carriage, recoil slide, and other appliances, as set out in the schedule of inventions presented by him to the Crown.

But Sir WILLIAM ARMSTRONG explained that by his system he in reality means the '*coil system*;' the '*construction of a gun by means of coiled tubes*' (3,491). The essential part, he says, is the *construction*; the mode of *rifling* is subordinate; and neither muzzle-loading nor breech-loading is peculiar to his system (3,495). *If this be so, it would* appear that the Committee of 1858, who acted under the order of the Secretary of State to select the best form of *rifling*, had in reality overlooked their directions, and confined their attention to *the welded coil*, of which Sir WILLIAM ARMSTRONG does not profess to be the discoverer, and which the Ordnance Select Committee of the War Office have reported to be the same as that previously used by Captain BLAKELY (see *ante*, Part II. chap. i. p. 91, and chap. ii. p. 105, *n.*). Again, if 'breech-loading is not essential,' then the lead-coated projectiles

authority of officers engaged in active service, in correction of the opinion expressed unfavourably of the ability of his guns to endure exposure to rough treatment in the fields, and shows that in China they had been dragged over swamps and covered with mud, without any impediment to their use in action immediately after.[1]

As to the Whitworth gun, in comparison with his own, Sir William is still doubtful of the tenacity of homogeneous metal, of which it is made.[2] He objects to the polygonal system of rifling,[3] disapproves of the mechanical fit of the projectile, and repeats his apprehension of its liability to accelerate injury by friction.[4] But unfortunately, as he was obliged to point out, his arguments on these points were delivered before a tribunal which, though highly competent to investigate the subject committed to them, namely, the recent *expenditure* upon rifled ordnance and its results, was neither constituted nor qualified to enter into the profounder enquiry of the scientific construction of artillery.

On the paramount question, whether the government,

which were to be forced through the fluted bore by that method cannot be said to be a part of his 'system' any more than the rifling. Submitted to a *soritic* process such as this, the claims of Sir William Armstrong in 1858, instead of resting on the 'origination of a system,' as described by Captain Jervis, would dwindle down to the mere forging of a gun out of welded coil; whilst Mr. Whitworth in 1863 stands as the producer of a gun, and the inventor of a system of rifling, as well as of a form of projectile the power and penetration of which no one is disposed to call in question.

[1] *Evidence, &c.*, 3,228, p. 144.

[2] *Ibid.*, 3,227.

[3] *Ibid.* 3,164, 3,925.

[4] *Ibid.* 3,949.

after four years of costly labour, are yet in possession of a gun able to pierce an armour-clad ship, or the 'Warrior' target, Sir William Armstrong states that although there are guns in existence which can do this, *there are no such guns in the service, and we have never been in a condition to introduce them.*[1] It is not unnatural that the country after such a declaration should require to know the cause of the obstruction? why, after such profuse outlay, are the guns we have got unfit for the work required of them; and why are those that have actually done it still excluded from the service?

So far as his own guns are concerned, Sir William Armstrong explains that armour-plating is even a greater novelty than rifled ordnance; that neither when his system was adopted in 1858, nor since, has it been determined what is the precise volume of iron to be pierced, and how therefore, he asks, 'can he be expected to produce a pattern for a gun the data for defining which do not even now exist.'[2] He has nevertheless a gun of his in progress which he relies on to penetrate armour-plate[3]; and should it succeed, we should then have *two* pieces of ordnance—it and the Whitworth—both superior, for this all-important purpose, to anything yet in possession of the nation. Surely *something* must be astray in a system which lands us in these incongruous results!

[1] *Evidence, &c.* 3,225, p. 141.

[2] *Ibid.* 3,226, p. 141.

[3] See *ante*, pp. 216, 306, 308. For the performance of this gun since, see *ante*, p. 308.

Meanwhile it has been stated as a matter of grave import that the accidents, occurring from time to time with the Armstrong gun on board ship, have had the effect not only of disquieting the officers, but of more or less impairing the confidence of the crews in its efficacy and in their personal safety in using it. In the course of the enquiry of the House of Commons' Committee in 1863, it is observable that of the naval officers examined all spoke guardedly in praise of the gun, and the majority openly in allusion to its defects. The First Lord of the Admiralty himself, declared 'that we want it strengthened in order to give the men perfect confidence.'[1]

It implies no imputation of want of courage on the part of sailors to say, as Captain Seymour, R.N., says, that after seeing an accident with one of these new and unknown weapons, the men would proceed with a certain amount of distrust to fire another.[2] Captain Jerningham, R.N., says, that acting under instructions to watch and report upon flaws he 'always felt that he would rather Sir William Armstrong should fire such guns himself!'[3] And so it may prove amongst the crew—the careless and unobservant will not shrink, because they are unaware of the danger; but the intelligent will be distrustful from a perception of the risk. Captain Hewlett, of the 'Excellent,' than whom no one has expressed a higher approval of the Armstrong

[1] *Evidence of the* Duke of SOMERSET, 5,139.
[2] *Evidence, &c.*, 2,318.
[3] *Ibid.* 3,655.

guns, says, 'although his own men and officers have the most perfect confidence in them, the general opinion of the navy is rather adverse; they are frightened, from one or two accidents, and the feeling of the fleet now is rather against them.'[1]

This apprehension, if allowed to take root and spread, would in time be disastrous; the intrepidity of a man in actual conflict is sustained, not merely by the possession of the best possible weapon, but by *the consciousness that it is the best*; and in proportion to the courage inspired by this belief would be the opposite feeling of discouragement and dismay if taught to think that the enemy had a *better*.

The restoration of confidence can only be accomplished by the early adoption of a policy different from that which has heretofore prevailed. The country must avail itself of the genius and discoveries of other inventors, by suspending the practical monopoly of one. Parliament must sustain the great officers at the head of the army and navy in instituting an entirely new mode of investigation, such as that recommended by the late Committee of the House of Commons, under which 'without prejudice or partiality, the different systems, not of Sir William Armstrong and Mr. Whitworth only, but of Mr. Bashley Britten, Captain Blakely, Mr. W. Richards, and other able men whose minds are now engaged on ordnance questions, may be fairly experimented upon.'[2]

[1] *Evidence, &c.* 3,420.
[2] *Report, &c.*, p. viii.

To ensure reliance in the issue of such an enquiry, the same Committee intimate with sufficient clearness, that 'no trials can be altogether satisfactory to which, under proper restrictions, the scientific public are not admitted;'—but the change to be reassuring must go somewhat farther. It will not suffice to permit the presence of scientific men only as spectators; they ought to be called in as umpires, and, at whatsoever sacrifice of conventional feeling, they must be associated and identified with the judgment of the new tribunal.

One 'lion in way' the nation must be resolute to confront; *the expenditure already incurred must be regarded as a thing of the past.* In the terse terms used by the present Superintendent of the Royal Factory at Woolwich, we must be content to 'let bygones be bygones with respect to the manufacture of Ordnance.'[1] And, after all, the experience gained, as Mr. Anderson reminds us, will be fraught with advantage when we come to take a fresh departure; and the disappointments endured will serve as so many beacons to warn us off from the track of former failure. Nor will the previous outlay be altogether lost; the material, the machinery, and other appliances created at Woolwich, will be still available; and the recent Committee of the House of Commons, whilst they are convinced that no reasonable expenditure for accomplishing this great object would be refused by Parliament, suggest that 'the present interruption of the manufacture of Armstrong guns at Woolwich affords a good opportunity for

[1] *Evidence, &c.*, Mr. ANDERSON, 753.

devoting the resources of that establishment to promoting renewed experiments.'[1]

One important step has already been taken in this direction; shortly after the startling events at Shoeburyness, at the close of 1862, when contrary to general expectation the armour-plate of the 'Warrior' was not only pierced by Whitworth shot, but penetrated by Whitworth shell, Her Majesty's Government came to the resolution to reopen the former settlement of 1858, so far as to authorise the institution of a series of trials to determine the relative excellence of the Armstrong and Whitworth systems. These comparative experiments are now about to commence. They will be conducted, not by the usual Ordnance Committee, composed exclusively of military and naval officers, but by another specially named, with whom two scientific civilians have been associated, Mr. John Penn and Mr. Pole, the former distinguished in the highest walks of his profession as a mechanical engineer. The programme of tests to which the guns are to be subjected will doubtless include every point essential to determine all questions of construction, velocity, range and precision; rapidity of firing, powers of destruction, and length of endurance. The issue of this important contest will be watched by the public with profound and unwonted interest—but the result, to whichever side victory may incline, must not be permitted again to close the gates against the honourable ambition of other aspirants. Sir William Armstrong and Mr. Whitworth are but

[1] *Report, &c.*, p. viii.

two out of those clamouring for admission; others in due course of time will advance their pretensions, and whatever be the result of the approaching trial, whether it attest the superiority of the Armstrong gun, or point to its supersession by the Whitworth; no judgment, *as between them*, must preclude the just claims of other rivals to an equally dispassionate scrutiny.

'Finality,' it has been said by Sir William Armstrong, 'is a word that ought to be unknown to science;' but this, like other propositions equally sound in the general, admits freely of exceptions in the particular. In Sir William's own factories there must be workmen to-day using tools so simple, yet so fully adapted to special purposes, as to be almost identical with those in use by their progenitors ages ago. The disinterred utensils of extinct races, the implements discovered in the tumuli of Asia, and in the earth mounds of the Mississippi; even the instruments found in the tombs of Etruria and Upper Egypt, as well as in the dwellings and workshops of Pompeii, exhibit combinations of mechanical parts as effective for their objects as those employed at the present time. There is no reason why similar excellence should not be attainable in ordnance; nor why science should not be so successfully applied to the construction of large guns as to render them by a combination of *strength and simplicity* so nearly perfect as practically to require no farther improvement. But till that point shall have been attained, competition must remain open; and whatever be the temporary inconveniences of

[1] *Letter* of Sir William Armstrong to *The Times*, Nov. 27, 1861.

change, the abiding interests of the country will henceforth require that the man who reaches the high eminence of giving his name to the arms under whose protection the nation reposes should hold it by no other tenure than that of uncontested superiority.

INDEX.

INDEX.

LONDON
PRINTED BY SPOTTISWOODE AND CO.
NEW-STREET SQUARE